Electronic scientific and practical journal

INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

#26 (2024)
August '24

WWW.SMART-SCM.ORG
ISSN 2708-3195
DOI.ORG/10.46783/SMART-SCM/2024-26

ISSN 2708-3195
9 772708 319005

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

Electronic scientific and practical publication in economic sciences

Electronic scientifically and practical journal “Intellectualization of logistics and Supply Chain Management” included in the list of scientific publications of Ukraine in the field of economic sciences (category "B"): **Order of the Ministry of Education and Culture of Ukraine dated October 10, 2022 No. 894 (Appendix 2)**

Field of science: Economic.
Specialties: 051 – Economics; 073 – Management

ISSN 2708-3195
DOI: https://doi.org/10.46783/smart-scm/2024-26

The electronic magazine is included in the international scientometric databases:
Index Copernicus, Google Scholar

Released 6 times a year

№ 26 (2024)
August 2024

Kyiv - 2024

Founder: Viold Limited Liability Company

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

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

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

Electronic scientifically and practical journal "Intellectualization of logistics and Supply Chain Management" included in the list of scientific publications of Ukraine in the field of economic sciences (category "B"): ***Order of the Ministry of Education and Culture of Ukraine dated October 10, 2022 No. 894 (Appendix 2)***

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DOI: https://doi.org/10.46783/smart-scm/2024-26
e-mail: support@smart-scm.org
тел.: (063) 593-30-41
https://smart-scm.org

Contents

UDC 8.45:37.011.2:378
DOI: https://doi.org/10.46783/smart-scm/2024-26-8
JEL Classification: M51, J44, J24.
Received: 8 August 2024

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ADAPTATION OF LOGISTICS MANAGERS' COMPETENCY MODELS TO INDUSTRY 5.0 CHALLENGES

Mariya Hryhorak, Marina Pichugina. "Adaptation of logistics managers' competency models to industry 5.0 challenges". *Radical geopolitical and geoeconomic transformations in the global economy are disrupting established economic ties and traditional routes of global commodity movement. Rapid technological changes, accelerated development of e-commerce, omnichannel strategies, and the sharing economy have contributed to increased demand for automation, robotization, and digitalization of logistics activities and supply chain management. These factors prompt the renewal and adaptation of the competencies set for logistics managers and, consequently, academic educational programs. The aim of the conducted research was to identify the impact of Industry 5.0 on the formation of the logistics personnel competency system, and to develop a new competency model considering rapid changes in technology, market conditions, consumer sentiments, and the regulatory environment. The research methodology combines theoretical analysis (theoretical generalization, analysis and synthesis, comparison, and grouping) with empirical research. As a result, existing and future trends in the logistics industry development were summarized, a comparative analysis of the competencies of logistics managers and engineers was conducted, and a tendency for their convergence under the influence of the transition from Industry 4.0 to 5.0 was identified. The developed comprehensive competency model for logistics managers in the context of Industry 5.0 allowed for improving the content and structure of the "Logistics" educational program at the National Technical University of Ukraine, determining the ratio between general and professional skills, the set of necessary tools and technologies required for developing and implementing logistics solutions, stimulating students to improve their knowledge, skills, and abilities, as well as orienting them towards effective professional activity in the future.*

Future research is reasonable to focus on evaluating new technological courses' effectiveness, developing interdisciplinary teaching methods, integrating practical experience, incorporating sustainability and social responsibility, and creating innovative assessment techniques to ensure curricula meet evolving labor market demands and prepare students for real-world challenges and new Industry 5.0 requirements.

***Keywords**:* Geopolitical transformations, Geo-economic changes, Logistics, Global economic relations, Industry 5.0, Digitalization, Robotization, Supply chains, Competencies of logistics managers, E-commerce, Competency model, Technological changes, Labor market, Sustainable development, Innovative assessment methods.

Марія Григорак, Марина Пічугіна. «Вивчення динаміки основних показників діяльності транспортних підприємств в умовах впровадження інновації». *Кардинальні геополітичні та геоекономічні трансформації, що відбуваються в глобальній економіці, руйнують усталені господарські зв'язки та традиційні маршрути глобального товарного руху. Швидкі технологічні зміни, прискорений розвиток електронної комерції, омніканальних стратегій та економіки спільного користування сприяли зростанню попиту на автоматизацію, роботизацію та цифровизацію логістичної діяльності та управління ланцюгами постачання. Ці фактори спонукають до оновлення та адаптації сукупності компетенцій менеджерів з логістики і, відповідно, академічних освітніх програм.*

Метою проведенного дослідження було виявлення впливу Індустрії 5.0 на формування системи компетенцій логістичного персоналу, розробка нової моделі компетентності з урахуванням швидких змін в технологіях, ринкових умовах, спочивчих настроях та регуляторному середовищі. Було розроблено методологію дослідження, яка combining theoretical analysis (theoretical generalization, analysis and synthesis, comparison, and grouping) with empirical research. В результаті було узагальнено існуючі та майбутні тренди розвитку логістичної галузі, проведено порівняльний аналіз сукупності компетенцій менеджерів та інженерів з логістики і виявлено тенденцію їх зближення під впливом переходу від індустрії 4.0 до 5.0.

Розроблена комплексна модель компетентності менеджерів з логістики в умовах індустрії 5.0 дозволила удосконалити зміст і структуру освітньої програми «Логістика» Національного технічного університету України, визначити співвідношення між загальними та професійними навичками, сукупність необхідних інструментів та технологій, необхідних для розробки і впровадження логістичних рішень, стимулювати студентів для самовдосконалення своїх знань, вмінь та здатностей, а також орієнтувати їх ефективну професійну діяльність в майбутньому.

Майбутні дослідження доцільно зосередити на оцінці ефективності нових технологічних курсів, розробці міждисциплінарних методів навчання, інтеграції практичного досвіду, включенні сталого розвитку та соціальної відповідальності та створенні інноваційних методів оцінювання, щоб забезпечити відповідність навчальних програм мінливим вимогам ринку праці та підготувати студентів до реальних викликів і нових вимог Industry 5.0.

Ключові слова: Геополітичні трансформації, Геоекономічні зміни, Логістика, Глобальні господарські зв'язки, Індустрія 5.0, Цифровізація, Роботизація, Ланцюги постачання, Компетенції менеджерів з логістики, Електронна комерція, Компетентнісна модель, Технологічні зміни, Ринок праці, Сталий розвиток, Інноваційні методи оцінювання

Introduction. The world is undergoing a profound geopolitical and economic transformation, with far-reaching consequences. International scientific and analytical centers, including IBM Institute for Business Value [1], «Think 30 Conference» [2], Global Solutions Initiative [3], and others, strive to understand the essence of these profound changes, seeking solutions for a "multi-crisis" era and propose new approaches and mechanisms to ensure sustainable economic development. The ongoing geopolitical tensions, including the confrontation between the West and the South, military conflicts, and trade wars, are disrupting global supply chains and logistics, destroying established economic ties and routes of global commodity movement. International supply chain schemes are

changing due to the cessation of links located in rival countries, reshoring, or friend-shoring or near-shoring. As the world economy fluctuates between the interdependence of global supply chains, the surge in domestic production and protectionism, logistics companies continue to provide flexibility and commodity movement efficiency, designing supply networks to meet real-time demand.

Ukraine is currently caught in the crossfire of these tectonic shifts, which creates both additional threats and opportunities for the country to become home to many businesses. Ukrainian logistics as a whole has adapted to the new realities and is successfully functioning under martial law conditions. The industry is recovering and integrating into the European and global transport and logistics network. Domestic agro-industrial holdings, trade and production companies, and developers are making significant contributions to the development of Ukrainian logistics. Despite difficult circumstances, new transshipment complexes are being built in Ukraine, and warehouse hubs and vehicle fleets are being modernized. Moreover, some companies are creating their own fleets, investing billions of hryvnias in development, and, given this, need to establish effective public-private partnerships and expect further European integration reforms. The movement towards European integration activates shifts in industry, in particular, stimulates the production of more technological products, the implementation of joint production and innovation projects in promising sectors of the economy, and accelerated movement from Industry 4.0 to Industry 5.0.

One of the key factors in making decisions about the possibilities of relocating production to Ukraine is the quality of human capital and competence in logistics and supply chain management. Currently, there are many business programs, seminars, and training sessions that allow the development of specific professional and general competencies of logistics specialists. A special role in training personnel for the logistics sector belongs to academic education, which, on the one hand, must respond to labor market demands, and on the other hand, be proactive, take into account global and national trends in industry development, and form competencies for the future. To train effective logistics managers, educational programs must adopt a competency-based approach. This means designing curricula that align with the specific skills needed by the industry, considering factors such as labor market demands, societal expectations, and the evolving landscape of logistics services. It is very important to take into account the speed of changes occurring in the logistics business environment and adapt the content and quality of specialist training in accordance with these changes and trends.

It is worth noting that the study of the transformation of logistics managers' competencies in the face of modern challenges is relevant for several reasons:

Firstly, modern technologies such as automation and robotics, artificial intelligence, big data, the Internet of Things, and others are radically changing logistics processes. Logistics managers must possess new technical knowledge and skills to effectively use these technologies in their work.

Secondly, rise of online shopping, the integration of online and offline channels, and the sharing economy are transforming the way businesses operate. This requires logistics managers to adopt new approaches to supply chain management and optimization of logistics operations.

Thirdly, business globalization requires logistics managers to understand international markets, legislation, and cultural aspects. This requires knowledge of international logistics, risk management, and global supply chains.

Fourthly, in the context of rapid development of scientific and technological progress, technological structures, and the global transition from Industry 4.0 to Industry 5.0, logistics is a driver of economic growth and a connecting link for various industries,

providing services that support core production and commercial activities, and can also contribute to increasing market share and gaining competitive advantage. The logistics industry in recent years can be characterized by three elements: growing customer requirements and expectations, sustainable development with the application of environmental solutions in logistics processes, and the use of innovative technologies that support the organization and execution of tasks.

Fifthly, growing attention to environmental responsibility and sustainable development requires logistics managers to have new competencies in green logistics, waste management, and carbon footprint reduction. The importance of social responsibility and ethics in logistics operations is also increasing.

The above indicates the chosen research direction.

Literature Review. Leading scientists from various countries constantly pay attention to the study of the structure and necessary changes in skills and competencies in such a rapidly changing sector as logistics and supply chain management. Different authors at different times have identified different competencies as the most important in logistics and supply chain management. Back in 1982, Richard Boyatzis published the book "The Competent Manager: A Model for Effective Performance," which became the foundation for further development of competency models [4], including in logistics. Murphy and Poist substantiated that a successful logistics manager must possess a comprehensive skill set encompassing three primary areas: business, logistics, and management, known as the "BLM" framework [5]. Many scholars use the competency model for standard talent analysis in the logistics industry and pay great attention to general rather than special competencies.

For the purposes of our research, publications by Gammelgaard & Larson (2001) [6], Mangan i Christopher (2005) [7], Kisperska-Moroń (2010) [8], Derwik & Hellstrom (2017) [9], are important, as they summarized the set of necessary individual and professional competencies in the context of logistics and supply chain management.

The competence sets for logistics managers can vary significantly depending on the country due to regulatory requirements, level of technological development, market conditions, cultural characteristics, economic context, educational standards, and the globalization. These factors shape the specific skills and knowledge required for the successful logistics processes management in a specific context. Given these conditions, the results of studies on regional and national logistics labor market and, accordingly, the importance of various competencies for successful career growth conducted in Slovenia [10], Serbia [11], China [12], and Malaysia [13] were useful for us. In particular, researchers from China proposed a model of talent competency in logistics, including parameters of potential and personal traits such as team spirit, responsibility, and the ability to collect and analyze information.

Numerous interviews with business representatives confirmed that logistics specialists should possess cross-functional understanding of different business areas, strategic decision-making skills, communication, leadership and intercultural communication skills, as well as well-developed analytical and IT skills to manage the various tasks they face daily [14].

Anthony Clarke [15] identified 12 core logistics skills for an effective supply chain manager: collaboration and communication, financial management, inventory management, strategic planning, leadership and management, transportation management, problem-solving, warehousing and storage, supplier management, risk management, quality control, and data analysis. At the same time, skills needed for managing logistics processes and supply chains in the next 3-5 years include innovation implementation, big data analysis, crisis management, uncertainty

management, intercultural intelligence, management of global hybrid teams, human-centricity, and situational self-awareness.

According to Kotzab et al. (2018) [16], four types of competencies were identified:

- Professional competencies that contain knowledge and skills specific to the profession or position;
- Methodological competencies - the ability to apply methods for more efficient and effective work results, including information processing and systematization, problem-solving, solution creation, and decision-making;
- Social competencies refer to soft communication skills that include competencies such as group and relationship-oriented behavior, communicative behavior, cooperative behavior, perseverance, and the ability to resolve conflicts;
- Personal competencies related to the development of one's own personality within the work role, including the ability for self-reflection and self-organization to maintain motivation and desire to work.

Remarkably, while academic literature often emphasizes social skills, job advertisements reflect a greater demand for cognitive and meta-competencies, indicating a discrepancy between theoretical and practical requirements for logistics managers. For instance, Katiniene et al. (2021) identified working with people as the most important social competence in logistics and supply chain management, as this field is service-oriented [17]. Sapper et al. (2021) rated learning readiness as the most important personal competence, as they believe it is crucial for the dynamic field of logistics services, and interdisciplinarity will become the most significant methodological competence in the future [18]. Derwik, Hellström, Karlsson [14] also noted that the competencies required for logistics and supply chain management are sifting towards a combination of managerial, general, and behavioral competencies.

On the other hand, a survey of supply chain specialists, mainly in developed countries, showed that it is difficult to university graduates possess the set of practice skills. This is evidenced by the analytical reviews results of international associations such as Association for Supply Chain Management (ASCM), CILT (Chartered Institute of Logistics and Transport), CSCMP (Council of Supply Chain Management Professionals), European Logistics Association (ELA), FIATA (International Federation of Freight Forwarders Associations), and others.

One of the most systematic and comprehensive studies was conducted by Kuehne Logistic University (KLU), commissioned by the World Bank among the Logistics Performance Index countries, and focused on skills and competencies, hiring, and retention of logistics personnel worldwide [19]. This was the first attempt at a comparative analysis of skills and competencies in logistics worldwide, based on online surveys of logistics companies, the global Logistics Performance Index (LPI) results, as well as results of case studies, particularly in the freight transport sector. The project compared logistics skills and learning conditions in emerging markets in Africa, South America, and Asia with those in more developed countries in Europe and North America. Internal studies in some countries, such as China, India, the United States, the United Kingdom, Vietnam, and the Republic of Korea, showed that businesses have difficulties hiring personnel with the necessary skills in logistics and supply chain management. The development of logistics, particularly IT, requires new competencies that the existing workforce lacks. They argued that the problem is twofold. On one hand, positions are often simply vacant because there are insufficient personnel with appropriate skills and qualifications in the labor market. On the other hand, this skills deficit in the existing logistics workforce arises because a significant portion of personnel is not keeping up with technical innovations, operational procedures, and

changing market dynamics. The authors also note that most logistics-related activities are outsourced to the 3PL sector, where large 3PL companies with multinational coverage must "tune" their workforce according to the logistics characteristics of the countries in which they operate.

The need for digital skills was accelerated by the global Covid-19 pandemic, as many businesses were forced to use remote forms of employment and change supply chain strategies to become more flexible, resilient, and transparent (McKinsey, 2020-2022) [20]. The transformation of logistics managers' competencies in the digital era is characterized by the integration of traditional management skills with digital competencies, cognitive abilities, and understanding of environmental issues. The literature argues that these competencies are crucial for navigating the complexity of modern supply chains and achieving sustainable competitiveness. That is why recent studies on the competence of logistics and supply chain managers are associated with changes in technological paradigms, Industry 4.0 and 5.0. In particular, Wahab, Rajendran, and Yeap (2021) emphasized the need for retraining and requalification of logistics personnel in the 4th industrial revolution [21], and the article [22] emphasized the need for analytical skills and the ability to work with large database. Recent studies by research groups have combined Industry 5.0 with supply chain management [23, 24]. In this context, the research of authors who highlighted the importance of digital competencies as a significant catalyst for a sustainable transition of business models to Industry 5.0 is of scientific and practical interest, as well as those that concluded that developing economies should play an active role in shaping the future by creating social stability promoting policies, resource conservation, and achievement of climate goals, ensuring more productive manufacturing processes with less waste and energy consumption.

Pacher, Woschank and Zunk (2023) argue that Industry 5.0 and the associated transformation into Society 5.0 require a complete restructuring of the tomorrow's engineers' skills [25]. To this end, the authors created a competency profile for engineering education in industrial logistics and proposed approaches to assessing and measuring competencies. And Nayeri et al. developed a decision support system for studying the adaptive supply chain 5.0 based on Industry 5.0 in the healthcare system, so the study presents an adaptive supply chain 5.0 [26].

It should be noted that the problem of forming and developing the competence of logistics specialists also attracts the attention of Ukrainian scientists. Among recent publications, the following results are worth noting: articles [27, 28, 29] prove the relevance of information and communication skills for future managers, the work [30] proposes a "T9 Model" of competence for logistics managers, combining general management competencies, problem-solving competencies, interpersonal, and functional logistics competencies; publications [31, 32] focus on the processes of transforming professional competencies of logisticians under the influence of pandemic and military restrictions, as well as determine the impact of digital technologies in supply chain management on the formation of professional competence, trends in their development in the conditions of a recovering economy [33].

Thus, the literature review showed, on the one hand, the relevance of research on the transformation of logistics managers' competencies in a changing business environment, and on the other hand, the gaps and discrepancies between the competencies demanded by the labor market and the existing university educational programs, the lack of a comprehensive analysis of the impact of Industry 5.0 on the formation of competence of logistics and SC specialists. This conclusion prompted us to research this topic in more depth.

The aim of the research is to identify and analyze trends in the development of the logistics industry, summarize factors

influencing the set of logistics managers competencies, develop a competency model taking into account rapid changes in logistics services markets and Industry 5.0 technologies, as well as develop recommendations for adapting educational programs to new conditions.

Research Methodology. This study aimed to investigate how the competencies of logistics managers are evolving in the context of Industry 5.0. To achieve this, we employed a mixed-methods approach, combining theoretical analysis (theoretical generalization, analysis and synthesis, comparison, and grouping) with empirical research. The first stage involved a comprehensive analysis of existing scientific literature, and reports on the Industry 5.0 and its impact on the logistics managers competencies. This allowed for the identification of main trends, modern theoretical approaches, and practical solutions. To illustrate real examples of competency transformation in various companies, a detailed analysis of specific cases was conducted, primarily focusing on leaders in the logistics services market who have successfully adapted their business models to the new conditions of Industry 5.0. The second stage was dedicated to developing a new model of competency for logistics managers in the context of Industry 5.0 and ways to implement it at the National Technical University of Ukraine. The research results were interpreted considering the theoretical context of Industry 5.0 and the identified changes in the logistics managers competencies. This methodology allowed for a comprehensive approach to studying the transformation of logistics managers' competencies in the context of Industry 5.0, combining theoretical and practical aspects for a deep understanding and practical application of the results. It enables the construction of a new model of academic logistics education, taking into account the latest trends and prospects for industry development under the influence of business digitalization and rapid changes in the market business environment.

Research Results. Let's first consider the changes that have occurred in the global logistics industry over the past two years. It should be noted immediately that the key transformations in logistics activities are associated with the growing pace of digitalization in managing global and regional supply chains, active implementation of modern digital technologies in the activities of logistics operators, ensuring continuity and the need for rapid adaptation to changing business conditions. It can be unequivocally stated that technologies are making a real revolution in logistics and supply chain management, as they automate processes, improve visibility and transparency of all stages of product movement, and allow for real-time data analysis and tracking.

Similar changes are occurring in the logistics industry of Ukraine, but they have their own peculiarities related to military actions. According to the results of the industry study "Infrastructure Index 2023" [34], conducted by the European Business Association together with law firms Arzinger and Sayenko Kharenko, in 2023, 79% of surveyed logistics companies did not stop their activities and continue to operate, 13% stopped work but have partially resumed, and 6% stopped work but have fully resumed. The work of 2% of companies is currently suspended. According to official statistics, 9 out of 10 largest logistics companies specializing in transportation and cargo have significantly increased their activity (according to YouControl data).

According to the State Statistics Service, from March to December 2023, 282.4 million tons of cargo were transported by all types of transport, which is 22% more than in the same period of 2022. In 2024, the positive "cargo" trend continues. This is clearly demonstrated by the results of the main segment of cargo transportation - railways, which traditionally accounts for about half of the total volume of cargo transportation in Ukraine. In the first

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half of this year, Ukrzaliznytsia increased volumes by 90 million tons of cargo, which is 28% more than in the same period of 2023. At the same time, export transportations increased by almost 59% [35].

Table 1 summarizes the global factors influencing the transformation of the world market of logistics services, as well as identifies the peculiarities of these factors' impact on the logistics industry of Ukraine.

Table 1. The impact of global factors on the transformation of the logistics industry in Ukraine

Factors of Influence	Global Context of Changes	Ukrainian Context, Impact on Ukraine
1	2	3
Changes in supply geography and logistic flows reorientation	Closure or restriction of traditional transport flows due to military actions in certain regions (Middle East, Ukraine, Red Sea crisis, etc.). Economic sanctions, trade restrictions, customs procedures, and tariff barriers affect the accessibility of raw material markets and supplier selection.	1. Due to the war, many traditional global logistic routes became inaccessible for Ukrainian importers and exporters, forcing companies to reorient to new markets, particularly European, and seek alternative routes for export and import (using Danube River ports, opening new railway and road crossings to the EU, and road routes through Poland, Romania, and other neighboring countries). 2. Business relocation – moving production from Eastern and Southern Ukraine to the west, as well as to neighboring European countries, which changed the geography of both internal and international cargo flows. 3. Increasing role of domestic carriers in the Ukrainian market, growth of their market share, as foreign carriers are not interested in traveling to frontline areas like Kharkiv or Zaporizhzhia under war conditions. 4. Active use of combined cargo transportation schemes involving rail and river transport with access to EU ports and subsequent delivery of goods directly via European road and rail routes.
Growth of online trade	E-commerce is the new norm in the global logistics market. To synchronize the shopping ecosystem, the supply chain needs to provide a seamless omnichannel sales experience. Customers want fast and flexible transportation of goods combined with full control over the process chain.	Ukrainian logistics companies also strive to integrate various logistics services – warehousing, transportation, and customs – into a single platform, allowing operators more efficient supply chain management. The last-mile delivery segment is actively developing. The number of courier companies and express delivery enterprises is growing. Construction of fulfillment centers is resuming, and the volume of fulfillment services by logistics companies is increasing. Most large retail chains have transitioned to combining online and offline sales channels, stimulating demand for multichannel **logistics.**
Changes in consumer preferences	Individualization and personalization of customer service necessitate flexible and adapted logistics solutions. Requirements for speed and accuracy of order fulfillment are increasing, along with growing demand for express delivery.	Emergence of new types of logistics services, new market segments, diversification of logistics service providers' activities. Active expansion of Ukrainian postal and courier companies into markets of other countries ("Nova Poshta" currently has offices in 18 countries worldwide and delivers goods to 213 countries).

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Continue of table 1

1	2	3
Digitalization and innovation	Automation of logistics processes, use of GPS systems for monitoring vehicle and cargo movement, Internet of Things technologies, artificial intelligence, blockchain, which increases transparency and efficiency of supply chain management.	Leading logistics companies are actively implementing automated warehouse management systems (WMS), transport management systems (TMS), and supply chain management systems (SCM). The relevance of logistics process automation in Ukraine is intensified by the shortage of personnel in the industry and becomes key to the survival of logistics companies. In Ukraine, there is growing demand for digital solutions such as online platforms for cargo transportation management, drones for monitoring and delivery, IoT technologies, and blockchain for ensuring supply chain transparency. This contributes to the development of the IT sector and the implementation of innovative solutions in logistics. Logistics operators have emerged in Ukraine that implement the "data-driven organization" business model, where the IT department prepares models that allow individual departments in the company to analyze information and make decisions based on it (Rohlig SUUS Logistics company).
Risks and resilience of supply chains	Global crises have highlighted the importance of risk management and resilience, which involves diversifying suppliers, changing sources of goods supply, developing alternative routes and various scenarios for goods delivery.	In Ukraine, these factors have led to a rethinking of approaches to risk management, including creating backup stocks, diversifying suppliers, and developing new resilience strategies. At the same time, this has necessitated the activation of humanitarian logistics, as well as increased volumes of consolidated cargo transportation. This applies both to the segment of truck transportation (LTL – Less Truck Load) and container transportation (LCL – Less Than Container Load).
Impact on human resources	Changes in the global labor market caused by the pandemic and conflicts have led to changes in employee competency requirements.	Migration, mobilization, and changes in the economic situation have led to a redistribution of human resources and an increase in labor shortages. Due to the lack of professional staff, one of the key tasks today is to increase the involvement of women in so-called "male" work and adapt people with disabilities to logistical work processes. This increases the demand for retraining, learning new competencies, and implementing new approaches to human resource management.
Changes in infrastructure development priorities	Global investment flows are increasingly directed towards the development of critical infrastructure objects. Introduction of new types of transport (electric vehicles, drones, and autonomous vehicles).	Ukraine needs to rebuild destroyed infrastructure, attract international aid and investors, and develop recovery strategies that include modern infrastructure solutions aimed at improving the efficiency of logistics processes. Development of new transport routes and transport corridors (expansion of the pan-European TEN-T network to Ukrainian territory, formation of new "grain" corridors, etc.). Ukraine has a chance to become a world leader in the use of drones and unmanned systems for supplying military and civilian objects.

End of table 1

1	2	3
Environmental and sustainable practices, implementation of resource and energy-efficient technologies	Growing emphasis on sustainable development, environmental norms, and carbon emission reduction, requiring new approaches to supply chain management. Logistics companies are responding to this trend by developing environmentally friendly logistics solutions.	Active involvement of Ukrainian companies in the European Green Deal. The need to implement sustainable practices for entering international markets. Use of ESG criteria for selecting investment projects for post-war infrastructure reconstruction. Destruction of energy facilities and reduction in energy generation encourages Ukrainian enterprises to save energy and use alternative energy sources.

Source: (summarized by [1, 2, 3, 20, 35, 36])

The factors listed above necessitate significant transformations in the system of personnel training for the logistics industry, including higher education, as the implementation of digital technologies and digital solutions requires new knowledge and skills. On the other hand, transformations occur due to the introduction of innovations in business conduct and strategic supply chain management, which demands new competencies in data and analytics, strategic thinking, and the ability to quickly adapt to changes in a dynamic business environment. The first factor is more related to the concept of Industry 4.0, as it emphasizes technological solutions. We associate the second factor with the transition to Industry 5.0, which draws attention to socio-economic factors of industrial sector development and long-term human development. Some scientists believe that both industries should coexist, as the first is aimed at technological control, while the second focuses on values and societal needs [37].

Industry 5.0 has three main characteristics: human-centricity, resilience, and sustainability (European Commission, 2022 [38]). Human-centricity means that machines will be used to perform difficult, repetitive, or monotonous tasks, while humans will focus on more stimulating and creative work. Resilience refers to companies' ability to cope with turbulence and unforeseen situations and recover from unexpected events or problems. Sustainability emphasizes sustainable development and reducing the harmful impact of economic activities on the environment [24, 25, 39, 40].

By analogy, the term "Logistics 5.0" is used to denote a new stage in the development of logistics theory, which takes into account the impact of digital technologies, particularly artificial intelligence, data analytics, blockchain, and other innovations on logistics systems and processes. Logistics 5.0 aims to create even more intellectualized and automated logistics systems capable of adapting to market changes and providing higher efficiency and flexibility. It concerns not only individualized product distribution, inventory management and warehousing, or optimization of transport processes but also the interconnection of data, machines, and people in all logistics operations carried out in supply chains [39]. An attempt to explain the difference between Logistics 5.0 and Logistics 4.0 was also made by authors [41], who emphasized that the concept of Logistics 5.0 reflects the features of logistics in Industry 5.0.

It should be noted that some experts believe that Industry 5.0 is not timely for Ukraine, as most sectors of the economy are at the stage of industrial development 3.0. However, we believe that in the logistics sphere, there are real prerequisites for implementing the basic principles and technologies of the new technological order. The post-war reconstruction of the country's economy, primarily infrastructure, will require saving both natural and financial resources, adhering to the UN sustainable development goals and sustainable practices of the

European Union, integrating Ukrainian enterprises into international supply chains, and so on. The logistics industry operates in very specific conditions as it acts as a link in supply chains in various sectors of the economy, must meet the requirements of individual clients it serves on behalf of commercial enterprises, and is responsible for its own actions towards society and the economy by adapting to legal requirements, environmental and social trends.

Summarizing the research results of various authors, the main characteristics of Logistics 5.0 can be defined as follows:

– Integration with machine learning and artificial intelligence: The use of machine learning algorithms and artificial intelligence allows logistics systems to analyze large volumes of data, forecast demand, and optimize solutions in real-time.

– Autonomous transport and warehouse equipment: The development of autonomous vehicles and robotic warehouse management systems allows reducing costs and increasing the productivity of logistics processes.

– Blockchain and data security: The use of blockchain technology to ensure security and reliability of data in logistics systems, as well as to ensure transparency and traceability of supply.

– Individualized and personalized services: The application of data analytics and artificial intelligence allows logistics companies to create individual and personalized solutions for clients, increasing customer satisfaction and competitiveness.

Thus, Logistics 5.0 is characterized by a higher level of intellectualization, automation, and digitalization in logistics systems, allowing enterprises to be more flexible, efficient, and competitive in the market.

The above indicates the need to develop new competency models for logistics personnel and adapt existing educational programs for training logistics specialists to the changes that are already occurring, as well as to consider the trends of future logistics.

Currently, in the higher education system of Ukraine, there are several conceptual approaches to training specialists for the logistics industry:

A) Training of logistics managers, which is implemented as a separate educational program within the specialty 073 "Management",

B) Training of logistics engineers, which is implemented within the specialty 275.03 "Transport Technologies",

C) Training of economists within the specialty 076 " Entrepreneurship, Trade, and Exchange Activities ".

Each of these approaches has its advantages and weaknesses, depending on which aspects of logistics and management they choose to work on. Managers focus on managerial and strategic aspects, while engineers focus on technical and procedural aspects. Table 2 presents research results that, in our opinion, best reflect the competency requirements for logistics managers and engineers.

Summarizing the results of these studies, there is a convergence of competency sets for managers and engineers in logistics. Ideally, combining both approaches can ensure effective management and improvement of logistics processes. The main reasons for this convergence are:

- The growing role of digital technologies in logistics activities, as automation, robotics, the Internet of Things, data analytics, and artificial intelligence have a significant impact on both managerial and technical aspects of logistics;

- The need to integrate technologies into strategies, which involves using digital technologies to improve efficiency, reduce costs, and increase the speed of goods movement;

- The increasing complexity of logistics systems, and managing such systems requires knowledge of both managerial and technical-technological aspects;

- Data collection and analysis technologies are becoming critically important for decision-making in logistics, as

the widespread use of automated management systems for transport, warehouse, and other logistics operations has contributed to the accumulation of large volumes of information that can be used to optimize business processes in supply chains and transport-logistics systems at various levels;

- The need to adapt to rapid changes in the logistics business environment, which involves using new technologies to develop alternative logistics solutions, considering risks, and preventing possible disruptions in both global supply chains and at the regional level.

Table 2. Comparative analysis of competency sets for logistics specialists

Skills of logistics and supply chain management managers (based on [21])	**Skills of logistics engineers (based on [42])**	**Skills of managers-economists (based on [43])**
Soft skills		
Supply chain analytics Technological ability Teamwork skills Customer orientation Leadership qualities Interpersonal communication skills Personal skills Creativity and resilience Negotiation skills Communication skills Emotional intelligence Adaptation skills Time management Knowledge of new social and digital media	Effective communication Problem-solving and critical thinking Adaptability and flexibility Team collaboration and leadership Time management and prioritization Attention to detail and accuracy Customer service orientation Conflict resolution and negotiation Cultural awareness and global perspective Continuous improvement and learning	Critical/analytical thinking Ability to learn, self-learn, and re-learn Ability to work in a team Planning and task prioritization Adaptability and flexibility Attention to detail Independent decision-making Problem-solving Communication skills Leadership and initiative Time management Emotional intelligence Negotiation Ability to build interpersonal relationships
Professional skills		
Supply chain analytics Demand and supply forecasting Project management Transportation/fleet management Warehouse management Asset and inventory management Reverse logistics	Supply chain management Transportation planning and analysis Warehouse Management Systems (WMS) Inventory management and optimization Data analysis and statistical analysis Enterprise Resource Planning (ERP) systems Geographic Information Systems (GIS) Process improvement methods (e.g., Lean, Six Sigma) Project management and planning Compliance and regulatory knowledge (e.g., customs, security)	Data analysis Business analysis Financial management Strategy and change management Project management Sales and negotiation Marketing analysis PR, communications, and copywriting Use of promotion channels Customer experience

Thus, the convergence of competency sets for managers and engineers in logistics occurs due to the growing importance of technologies and the need to integrate technical knowledge into management strategies. Logistics 5.0 requires new

competencies from managers that combine technological knowledge, analytical skills, managerial abilities, and attention to sustainable development. The competency model should take these aspects into account to ensure effective management of modern supply chains and compliance with new market requirements.

It should also be noted that the competency sets of logistics managers and engineers are constantly changing under the influence of modern challenges, technological innovations, globalization, environmental and social requirements, crisis situations, etc. This means that traditional competencies are being transformed and new competencies are emerging. For example, instead of simple supply chain management, modern managers must be able to implement and use digital tools for automating and optimizing supply chains, integrate artificial intelligence-based systems for real-time demand forecasting and inventory management. The implementation of intelligent transport systems that use Internet of Things technologies for real-time monitoring and optimization of transport processes includes automated vehicle management and unmanned systems for goods delivery. Modern automated warehouse management systems use robotic systems and drones to optimize warehouse operations.

Thus, the set of competencies of a logistics manager should be considered as an integrated system that helps achieve the organization's strategic goals in conditions of constant changes in technologies, market conditions, and challenges. This system can be described by a competency model that presents a structured description of knowledge, skills, behavioral characteristics, and other qualities necessary for successful performance of specific work tasks or achieving productivity in a certain position. Taking this into account, we have developed a new competency model for logistics and SC managers, which includes four important components: knowledge, skills, behavioral characteristics, and motivation (Fig. 1).

Therefore, logistics managers should know the evolution of logistics concepts and supply chain management, patterns of creation and development of logistics systems, characteristics and integration of business processes in supply chains, methodology for developing and making logistics decisions at strategic, tactical, and operational levels. In addition to subject area knowledge, logistics managers should have technical and technological knowledge, particularly organizational and technological schemes of logistics processes, features of using information and information-communication technologies for monitoring goods movement, data analysis and processing, demand forecasting and inventory management, transportation and warehousing management using automated and robotic systems, automation of production processes, etc.

The skills of logistics managers should be aimed at managing logistics processes and projects for developing logistics systems at micro-, meso-, and macro-levels, adapting to new technologies, forming innovative thinking, and understanding how innovations can affect logistics business processes and supply chain competitiveness.

Behavioral characteristics are oriented towards developing systemic thinking and interpersonal skills, primarily aimed at human-machine collaboration in automated and robotic logistics systems, effective communication in an environment where people and technologies interact, managing interdisciplinary and intercultural project teams, etc.

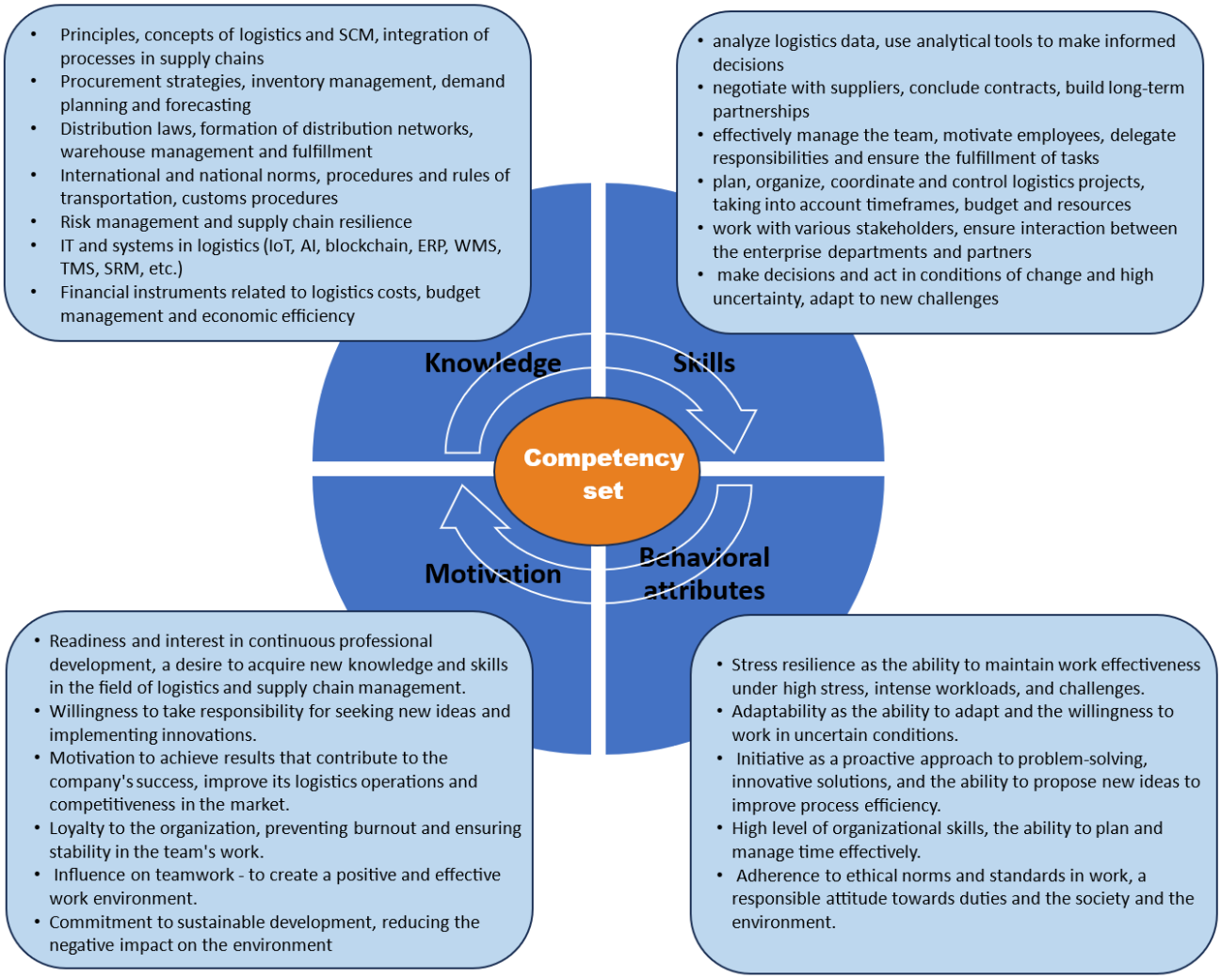

Figure 1 – Competency model for logistics and SC managers in Industry 5.0

The inclusion of the fourth component "Motivation" in the model corresponds to the modern understanding of competence, which can be described by the formula "I know, I can, I'm able to, and I want to," i.e., how capable a specialist is in applying acquired knowledge, abilities, and skills in real conditions of professional activity. Even if a person has a high level of knowledge and skills, without proper motivation, they may not use them effectively. In the proposed model, a logistics manager should have an interest in continuous professional development, strive to acquire new knowledge and skills in logistics and supply chain management, achieve results that contribute to the company's success, increase the efficiency of its logistics operations, and competitiveness in the market.

It should be noted that Industry 5.0 emphasizes the integration of technologies to increase efficiency and reduce negative environmental impact, which includes implementing sustainable practices in logistics and supply chain management. That is why logistics managers should be able to implement sustainable practices and solutions to reduce harmful emissions into the environment, demonstrate high ethical awareness and social responsibility in decision-making, and have a commitment to sustainable development as part of corporate culture and personal professional values.

The change in competency models for logistics managers necessitates adjusting academic training programs to prepare students for new requirements and realities of the profession. The proposed competency model for logistics managers has been implemented in the new edition of the "Logistics" educational program at the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute".

		Courses for bachelor's degree in logistics	Courses for masters's degree in logistics
Hard Skills	Understanding the concepts of logistics and SCM	Basics of logistics. Supply, production and sales logistics.	Sustainable supply chains strategic management. Environmental management.
	Management and optimization of logistics operations and business processes (transportation, warehousing, inventory management, order fulfillment, etc.).	Operational management. Transport logistics. Warehouse logistics. Reverse logistics. Quality management, lean production and logistics.	Logistics management. Demand forecasting and inventory management. Global Procurement in Supply Chains.
	Knowledge of international and national regulation of logistics activities and risk management.	International economic relations. Customs logistics. Risk management.	Global customs logistics. International settlement operations in logistics. International transport and logistics systems.
	Strategic planning and development of logistics systems, forecasting costs and optimizing budgets for logistics activities, increasing the supply chains competitiveness.	Enterprise economy. Company finances. Business forecasting. Integrated planning of logistics support for production.	Design of logistics infrastructure objects. Innovation technologies in logistics systems.
	Communication and partnership with suppliers, customers, and other stakeholders in changing market conditions.	Management. Marketing. HR management. Behavioral economics.	Reputational capital in logistics. Logistics consulting.
	Business analytics and modeling of logistics processes using digital technologies.	Business statistics. Economic analysis. Technology systems and digitization. IT in logistics.	Intellectualization of the logistics services market. Analytical statistics using the R language.
Soft Skills	Language and information communications	Language culture and business communication. Foreign language. Information systems and technologies. Digital transformations.	Foreign language for business communication.
	Self-organization and time management	Basics of a healthy lifestyle. Self-management. Recruitment. Career coaching.	Training "Logistics of crisis situations"
	Data analytics	Mathematics for managers. Probability theory and mathematical statistics for managers. Data visualization. Blockchain and artificial intelligence in business.	Training course "Critical thinking". Business analytics in logistics.
	Leadership and team development, use of agile project management technologies for rapid adaptation to changes, human-centric orientation of corporate governance and corporate social responsibility.	Leadership and business communications. Psychology of conflict. Training "Crisis communications". Creative management.	Logistics Cost Optimization Project Management. Corporate Governance

Figure 2 – Key competencies and academic disciplines from the educational program "Logistics" curriculum

The purpose of this educational program is to train specialists who possess systemic thinking and are suitable for professional logistics activities in various economic sectors, with a wide range of general and professional competencies, to provide entities of various organizational and legal forms with qualified personnel in the field of logistics process management. The uniqueness of the proposed program is due to its priority orientation on forming pro-innovative competencies of logistics managers capable of effective work using modern digital technologies and oriented towards partnership and interaction in supply chains. The program combines knowledge of management, logistics, economics, information technology, law, finance, operations management, etc. Figure 2 contains a list of key competencies and academic disciplines provided in the curriculum for educational program "Logistics".

Thus, an updated educational program is critically important for training logistics managers capable of successfully working in Industry 5.0 conditions and successfully coping with future challenges. It is adapted to modern requirements, includes new technologies, soft skills development, sustainable development, analytical abilities, and practical experience.

To verify the acquired knowledge and formed skills, a system of program learning outcomes is extremely important, which should be oriented towards fostering human-centricity, sustainability, flexibility, and digital transformation in logistics management. To better understand the needs and requirements of business, establish partnerships, and ensure the possibility of internships for students at domestic enterprises, we have developed a matrix of maturity of logistics competencies, which allows determining the degree of formation of knowledge, skills, and abilities. Usually, such matrices are developed by companies to identify the current level of competency maturity in the organization, identify weaknesses, and develop personnel development plans. This tool can be used by universities to evaluate the effectiveness of their educational programs, develop new courses, and improve forms and methods of classroom and independent work of students.

Table 3 presents our proposed maturity matrix of logistics managers' competencies, which provides for 3 levels of formation, as well as key performance indicators (KPIs) for measuring students' academic achievements and their ability for self-development.

For each level of competency, the main forms of classroom and extracurricular student work, incentives for obtaining in-depth knowledge and forming innovative thinking are defined:

A. Basic or initial level reflects a basic understanding of the main concepts and principles of logistics, knowledge of logistics processes, ability to develop and justify logistics solutions using basic information systems and procedures.

B. Advanced level involves a deeper understanding of various functional areas of logistics and integration of logistics processes with other business processes in supply chains, knowledge of international standards and best practices in logistics and supply chain management, ability to conduct data analysis to optimize logistics processes using various software.

C. Innovative level requires deep knowledge of the latest trends and digital technologies in logistics and supply chain management, the impact of Industry 5.0 on logistics processes, including the integration of people and technologies to create personalized solutions, ability to develop sustainable development strategies for logistics systems of various complexity levels, considering environmental, social and economic aspects, identifying ways to increase the efficiency of logistics activities and competitiveness of supply chains.

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Table 3. Structure of the maturity matrix of logistics managers' competencies (author's contribution)

Competences	**Levels of formed competences and learning outcomes**			**KPI**
	Basic	Advanced	Innovative	
Knowledge	Knowledge of the basics of logistics, concepts and principles of logistics, management of logistics business processes in supply chains	Deeper understanding of functional areas of logistics, integrated management of business processes in supply chains, development of logistics strategies and their impact on the competitiveness of supply chains.	Deep knowledge of the impact of Industry 5.0 concepts on logistics processes, including the integration of people and technology to create personalized solutions. The ability to develop strategies for the sustainable development of logistics systems, taking into account environmental, social and economic aspects.	Student success in basic courses. Solving cases, carrying out mini-researches, business games and trainings.
Skills	Mastering basic instruments and performing basic operations.	Successful solution of complex cases, data analysis and decision-making skills. Participation in thematic webinars and online courses.	Strategic thinking, development of innovative solutions, participation in interdisciplinary projects, initiation of real or simulated logistics projects.	Percentage of students.
Behavioral attributes	Communicative learners, responsibility and discipline, adaptability and ethical behavior (academic integrity)	Leadership qualities, creativity and innovative thinking, the ability to work in a team, taking into account the opinions of others, and contribute to the overall result	Strategic vision, emotional intelligence, flexibility and openness to change, adaptability to cultural contexts, participation in exchange and academic mobility programs.	Percentage of students.
Motivation	Attitude to learning, performance of classroom and independent tasks, discipline and personal responsibility.	Participation in extracurricular activities: student clubs, circles, conferences, competitions, workshops or internships in companies related to logistics.	Proactivity, leadership motivation in team projects, volunteering, participation in social and environmental projects, participation in global sustainable development initiatives.	Percentage of students

To assess the maturity of students' knowledge at different levels of competency, indicators (KPIs) of student success, individual student ratings, the proportion of students participating in various classroom and extracurricular activities, olympiads, competitions, business and scientific projects, academic mobility programs, etc. can be used. These KPIs will help track student

progress at each maturity level and ensure that curricula match their development.

The existing system of knowledge and academic skills assessment at KPI stimulates students' creativity. Students can receive bonus points in academic disciplines for participating in scientific work competitions on the subject of the discipline or for in-depth study of specific topics, the results of which are presented in the form of scientific theses, essays, presentations, scientific articles, etc., completing online courses on the subject of the discipline. There is also a system for recognizing learning outcomes acquired through non-formal or informal education.

It's also worth noting that NTUU "Igor Sikorsky Kyiv Polytechnic Institute" is a research university, which means it is not only a source of new knowledge and technologies but also a platform for developing skills that allow future specialists to successfully adapt and work in the conditions of Industry 5.0. The university has created an innovative ecosystem "Sikorsky Challenge Ukraine" (SCU), which currently unites structural units of the university (KPI Department of Innovation and Technology Transfer, KPI Research Division, KPI Intellectual Property Center, KPI TechnoHub, Sikorsky Challenge KPI Startup School, Institute of Advanced Defense Technologies), as well as 15 regional/city innovation clusters, dozens of enterprises, business associations, and foundations. Through conducting fundamental and applied research, the university contributes to the creation of new technological solutions and approaches, which are subsequently integrated into educational programs and prepare students for work in the modern digital environment. This allows students to acquire comprehensive competencies that meet the requirements of the modern labor market, where not only technical skills are important, but also the ability to integrate knowledge from various fields.

Conclusions and Further Research Prospects. Logistics as a field of professional activity is undergoing significant changes. The speed at which these changes are occurring is most striking, but at the same time makes logistics an interesting, dynamic industry that never stops and is always at the forefront of all global trends and challenges. In recent years, during the global Covid-19 pandemic, the intensification of trade wars and armed conflicts in various regions of the world, a volatile market environment, and significant uncertainty, logistics and supply chains have come to the forefront of special attention not only for businesses but also for international organizations and entire regions and individual countries. The issue of ensuring the continuity and sustainability of logistics processes has never been as critical worldwide as it has been in the last 2-3 years. Global transformations require logistics personnel to pay more attention to systematicity and speed of decision-making, control at all stages of the supply chain, the need to develop alternative scenarios for product movement, ensure flexibility and efficiency of product delivery to different regions of the world, and design supply networks to meet demand in real-time.

The analysis of the main trends in the development of the global logistics services market allowed us to identify and systematize key factors influencing the transformation of the logistics industry, as well as to investigate the peculiarities of these factors' manifestation in Ukraine.

It was proven that the processes associated with changes in technological structures and the transition from Industry 4.0 to Industry 5.0 have the greatest impact on the transformation of competence of logistics and supply chain management managers. This means that the importance of information and communication, digital, personal, and interpersonal skills is growing. Highly qualified specialists can stimulate technology development and develop digital logistics solutions for systems of various complexity levels, as well as effectively implement and use digital technologies for data processing, optimization of logistics

processes, cost reduction, and increasing the speed of product movement.

This means that traditional competencies are being transformed and new competencies are emerging. Instead of simple supply chain management, modern managers must be able to implement and use digital tools to automate and optimize supply chains, integrate artificial intelligence-based systems for demand forecasting and real-time inventory management. The implementation of intelligent transport systems that use Internet of Things technologies for real-time monitoring and optimization of transport processes includes automated vehicle management and unmanned systems for product delivery. Modern automated warehouse management systems use robotic systems and drones to optimize warehouse operations. In general, logistics and supply chain management managers need to learn to cooperate with artificial intelligence, using an approach known as "human-machine collaboration" or "collaborative intelligence," which manifests itself in the use of artificial intelligence to cover human weaknesses or automate routine tasks. Such a specialist must possess strategic thinking and creativity, while artificial intelligence can provide speed in processing large data sets, finding correlations, making predictions, and providing recommendations.

Summarizing the results of scientific research by many scientists and analytical reviews concerning the development and transformation of competency models for logistics personnel, the selection and assessment of the significance of general and professional competencies allowed us to develop an author's competency model for logistics managers, which represents an integrated system of structured knowledge, skills, behavioral characteristics, and other qualities necessary for the successful performance of specific work tasks. The novelty of this model is the separation of the "Motivation" component, which corresponds to the modern understanding of competence, which can be described by the formula "I know, I can, I am able, and I want." In the proposed model, a logistics manager should have an interest in continuous professional development, strive to acquire new knowledge and skills in logistics and supply chain management, achieve results that contribute to the company's success, improve the efficiency of its logistics operations, and enhance competitiveness in the market.

The changing competency models for logistics managers necessitate adjustments to academic training programs to prepare students for new demands and realities of the profession. The proposed competency model for logistics managers has been implemented in the new edition of the "Logistics" educational program at the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". The uniqueness of the proposed program is its priority focus on developing pro-innovation competencies of logistics managers, capable of working effectively using modern digital technologies and oriented towards partnership and interaction in supply chains. The program combines knowledge from management, logistics, economics, information technology, law, finance, operations management, and more. Industry 5.0 emphasizes the need to integrate advanced technologies such as artificial intelligence, robotics, and big data, necessitating the inclusion of new courses in educational programs aimed at developing relevant knowledge and skills. Moreover, it is important to develop interdisciplinary competencies that will allow students to combine technical knowledge with management and communication skills, which is particularly relevant in the context of modern challenges. Sustainability and social responsibility are central to Industry 5.0, requiring a revision of educational programs to account for environmental and ethical aspects, as well as providing students with opportunities to master sustainable development practices.

To better understand the needs and requirements of business, establish partnerships, and provide opportunities for

student internships at domestic enterprises, we have developed a matrix of logistics competency maturity that allows determining the degree of formation of knowledge, skills, and abilities. Three levels of academic competency formation are proposed, as well as key performance indicators for measuring students' academic achievements and their capacity for self-development. Due to rapid changes in technology and the business environment, the use of the logistics competency maturity matrix should promote the development of flexible thinking and adaptability in students, including strategic management, change forecasting, and crisis management. Participation in various business events, trainings, seminars, etc. will strengthen the practical component of the educational program, providing students with opportunities to gain real experience through internships, educational projects, business cooperation, and participation in mobility programs.

Thus, the proposed comprehensive approach, which involves developing a competency model for logistics managers in Industry 5.0 conditions, has allowed for improving the content and structure of the "Logistics" educational program, taking into account trends in the logistics services market and forecasts for the future development of the logistics industry. It has helped determine the relationship between general and professional skills, the set of necessary tools and technologies for developing and implementing logistics solutions, stimulate students to improve their knowledge, skills, and abilities, and orient them towards effective professional activity in the future.

Prospects for further research on improving educational programs considering Industry 5.0 requirements can be defined through several key directions. Firstly, it is important to investigate the effectiveness of implementing new technological courses and their impact on students' competency formation, which will allow assessing how well curricula meet modern labor market requirements. Secondly, attention should be paid to the interdisciplinary approach to learning, which is relevant in conditions of growing integration of various knowledge fields. Research can focus on developing and implementing teaching methods that promote students' skills in working at the intersection of different disciplines, as well as evaluating their effectiveness. Additionally, a promising direction is studying the integration of practical experience into the educational process, particularly through internships, business cooperation, and mobility programs, which will help identify best practices for preparing students for real challenges in professional activities. It is also worth continuing research on the impact of sustainability and social responsibility on the content of educational programs, as these aspects are gaining increasing importance in the modern business environment. Finally, research prospects may focus on developing innovative methods for assessing student competencies considering new Industry 5.0 requirements, which will ensure quality monitoring and correction of the educational process to achieve optimal training results. .

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