

The object of the study is the process of innovative and financial modernization of the transport system based on international technology transfer. The problem of innovative foundations of strengthening its competitiveness in the conditions of integration into the EU has been solved. The main results obtained: disclosure of the innovative essence of technology transfer, substantiation of the organizational and economic mechanism and systematization of demand factors of the transport system for technology transfer, its financial and investment support.

The obtained results are illustrated by a system of qualitative and quantitative indicators. It was established that during 2010–2019, the share of spending on the GDR in the national GDP decreased from 0.75 % to 0.43 %, but at the EU level it increased from 1.92 % to 2.14 %. The high dependence of countries on the transfer of technologies and innovations due to the negative values of their export and import balances has been proven. Their main share in 2020–2021 in the country falls on licenses – 51.39 % and 44.48 %, respectively, as well as franchises and trademarks – 38.55 % and 39.51 %, respectively. The results are explained by the lack of financial resources for the implementation of innovations, the lack of scientific research, etc.

The peculiarities of the conducted research are the use of a dynamic approach for the provision of a balance between innovations and sources of their financing, of strengthening the competitive positions of the transport system in the conditions of European integration. The scope of the results is the development of strategic innovative foundations for the transport system, and the conditions for their practical use are promising tools for financial and investment support

Keywords: international transfer, innovative technologies, national economy, transport system, modernization, competitiveness

INNOVATIVE AND FINANCIAL MODERNIZATION OF TRANSPORTATION SYSTEM BASED ON INTERNATIONAL TECHNOLOGY TRANSFER

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1. Introduction

Under the conditions of the knowledge economy, scientific and technological progress is the basis of extended social reproduction and ensuring the strategic competitiveness of enterprises. Globalization, the integration of economic relations, predetermines the possibility and need for movement, transfer, diffusion of innovations between regions, countries, their associations, or transfer (from the English word *to transfer*). The transfer of technologies is closely related to the global division of labor and performs important functions: it ensures an increase in the efficiency of reproduction due to the introduction of innovative processes in various types of economic activity; creates additional opportunities for sustainable development; increases adaptive changes to external changes and the ability to predict market conditions.

Technology transfer is one of the basic categories in the theory of the innovation process. It has gone through a long

path of evolution: from a linear character (an individual approach to the creation of individual innovations and their exchange) to a non-linear or triple spiral based on the partnership of science, business, and government. Under modern conditions, the role of innovative leadership based on the implementation of the results of scientific and technical activities in operational processes is growing among the factors of ensuring competitive advantages. Creation and commercialization of innovations, effective technological exchange will contribute to the structural shift of Ukraine's economy in the direction of high-tech export and import, its integration into world commodity markets. In these circumstances, the use of technology transfer by enterprises, including the transport sector, is timely. The relevance of the investigated issues will increase under the conditions of the post-war reconstruction of the economy through the provision of accelerated technological development, the restoration of the capacities of enterprises, and the improvement

of the competitiveness of domestic products on the domestic and foreign markets.

2. Literature review and problem statement

The issue of technology transfer management is the subject of consideration by many scientists. Their works differ significantly, as they are devoted to different aspects: theoretical, applied (taking into account the specifics of the industry), technical, economic, legal, etc. In theoretical terms, Chinese researchers [1] consider transport and logistics chains through the prism of systemic relationships with the circular economy, Industry 4.0, and technology transfer. In their opinion, the circular economy is necessary for the renewal of outdated business practices and the creation of new business sectors. These transformations should be based on the transition from the current linear paradigm of production and consumption to a non-linear creative paradigm based on innovative methods of reuse of intermediate and final products. Although the existing ideas are acceptable, they will need to be adapted to the conditions of martial law.

The applied results of the analysis of literary sources are presented below by individual types of transport.

First, air transport. The subject of study [2] is the transfer management of innovative changes in business processes and business functions of transport and logistics activities on the example of airlines. Innovative projects based on benchmarking are recommended for implementation in their activities. The main ones are individualization of customer service; improvement of their service level, IT technologies, e-business, mechanization of time-consuming processes; simplification of customs formalities; situational management of logistical flows of transportation based on sensitivity. The limitations of the study are the impossibility of reproducing the obtained results under the conditions of closing the sky for civil aviation due to the state of war.

Worthy of attention are proposals regarding the use of the transfer of balancing fuel pumping technologies known from foreign practice for implementation in Ukrainian aviation to solve the problem of energy saving [3]. Attention is focused on significant volumes of pollutant emissions of aerial aircraft during the stages of landing, taxiing, and take-off, and innovative technologies for their reduction, in particular, in the nitrogen part, are proposed [4]. Norwegian scientists [5] who have developed a model (AviTEAM – The Aviation Transport Emission Assessment Model) are also taking care of the problems of environmental safety of aviation, combating air pollution and climate change. It allows one to estimate different types of emissions from aviation activities based on flight paths, aircraft, engine types, and atmospheric conditions for automatic reduction. The advantage of the recommendations given in work [5] is a good agreement with the idea of sustainable development in terms of energy saving and greening of aviation transport, however, their insufficient economic justification should be attributed to the disadvantages.

The focus of authors of article [6] is the need to reform business models of air transport, which were used for a long period of time and turned out to be unsustainable under the conditions of COVID-19 and in the future. New transport and logistics technologies must compensate for airline losses from a reduction in cargo traffic and passenger traffic, increased competition from the entry of new players into the market, etc.

However, the specifics of the implementation of the proposed technologies under the conditions of extraordinary events, which include not only restrictions related to pandemics, but also to the conduct of military operations, are not specified.

Worthy of attention are opinions on the prospects for the development of electric aviation, which is a significant achievement of the modern aviation industry and includes several design concepts of electric aircraft, prototypes [7]. Its main advantages are environmental friendliness, significant reduction of harmful emissions into the atmosphere associated with traditional aviation. Restraining factors are the need to develop new certification standards, the creation of appropriate infrastructure, advanced battery technologies, electric machines, airframe and engine designs. However, the prospects for the creation of international standards for electric aviation and their adaptation in national legislation have not been outlined.

Second, road transport. In works [8], the technological interaction of passenger transport in a suburban transport and transfer terminal was improved. It is based on a mathematical model of the functioning of the stopping points of transport and transfer nodes and in the environment the PyCharm program, designed for simulation modeling [9]. The results make it possible to determine the planned range of vehicle maintenance based on accounting for the fluctuation processes of the formation of their arrival time and idle time at the transport interchange [10]. The value of building simulation-mathematical models would increase if economic indicators of the cost of transport services were included in them.

The authors of works [11, 12] calculated the efficiency of resource provision of stopping points taking into account the duration of passengers' stay at the transport and transfer hub, and also substantiated the criteria for choosing alternatives (interroute transfers or service stops) depending on the volume of passenger traffic. However, the limitations of the research of these authors [11, 12] are the failure to take into account the influence of innovative transport technologies on solving the specified problem.

The problems of digitalization of urban transport are taken care of by authors who investigate the issue of construction and interaction of distributed sensor networks in the architecture of the Internet of Things and systems of automated management of dynamic infrastructure objects [13]. In the work, the peculiarities and structure of multimedia flows of digital telemetry and packet data between controllers of sensor networks of urban transport in its safety management systems are investigated. Article [14] considers the use of advanced environmental technologies that counteract the process of transport of pollutants of transport origin in the surface layer of city blocks. Highly appreciating the technical and technological component of study [14], one should recognize the insufficient justification of the socio-economic efficiency of the proposed transport solutions.

In [15], based on a study of advanced technologies of unmanned public transport and cars, it was concluded that their availability can lead to a paradigm shift in the transport industry. But the question of the prerequisites for the spread of autonomous management of ground vehicles remained unresolved, given the existence of objective reasons, namely an increase in trips not related to work, a change in the times of their implementation, a decrease in the attractiveness of walking and cycling, public transport, etc.

Third, water transport. The authors of paper [16] note that for the vast majority of Ukrainian enterprises in the

industry, the transfer of innovative developments is the only opportunity to improve their technical and technological condition, the quality-of-service provision, and gain competitive advantages in the market. The organizational and economic mechanism of transfer of innovative developments of the water transport enterprise of Ukraine is also substantiated [17]. The paper discusses the creation and implementation of a system of transfer of energy- and resource-saving technologies for the development of the road and transport system of Ukraine [18], including with the participation of the National Technology Transfer Network (NTTN). Recognizing the importance of the developed recommendations, we consider it expedient to differentiate them for water transport enterprises that carry out international and domestic transportation.

Innovative environmental technologies designed to reduce carbon emissions in maritime transport are also an important subject of research [19]. The paper analyzes the relative importance of the determinants of maritime transport costs for trade and economic development and assesses the transmission channels and economic impact of carbon taxation on maritime transport costs. The technological development of sea transport is considered as a tool for improving safety by achieving a human-oriented sustainable transport environment [20], namely the FP7 project SEAHORSE (Safety Enhancements in transport by Achieving Human Oriented Resilient Shipping Environment). It transfers well-proven practices and methodologies from air transport to maritime transport by using sustainability engineering principles in an integrated multi-layered framework that ensures vessel operation and improves shipping safety. Given the established similarities, the development of multimodal transportation technologies with the participation of water and air transport enterprises is likely to be a promising direction for the development of the ideas presented in [20].

Fourth, railroad transport. The concept of sustainability of the freight transportation industry from a regional point of view [21] is applied to it, taking into account changes in demand in the long term. Statistical studies of the authors showed that the volumes of freight traffic have high elasticity to disturbances in other sectors of the economy. On the contrary, intermodal transportation is more stable. The development of the idea of eco-innovations in railroad transport [22], which consists in the implementation of new solutions and obtaining competitive advantages while reducing the negative impact on the natural environment, deserves attention. The idea is illustrated by the example of modified coal cars, where minor changes in the design of a coal car can affect the efficiency of freight transportation and help reduce environmental damage by reducing the carbon footprint. Despite the importance of the ideas of intermodal freight transportation with the participation of rail transport and their eco-innovations, the authors did not pay attention to the issue of cross-financing of passenger rail transportation at the expense of freight.

A study [23] on the relationship between the anthropogenic environment and integrated use of rail transport and bike-sharing (RTBS) during a single trip or journey allows people to seamlessly switch between rail transport and cycling for improved accessibility and convenience. Important is the study of the role of information sources about public transport and the perception of the quality of services in the suburban railroad [24]. Some heterogeneity was found

in the relative importance of attributes by information role: online-informed passengers care most about essential attributes, while traditionally informed passengers are more dependent on comfort. On-line sources of information turned out to be more important for urban rail transport, while off-line – for suburban ones. A clearer presentation of the content of a customer-oriented approach to rail transport management would increase the value of the ideas presented in this paper.

Based on our review of the literature, one should recognize the mostly retrospective partial character of their conclusions. However, awareness of innovative development strategies of the national economy requires determination of the development potential of its transport system.

3. The aim and objectives of the study

The purpose of this study is to improve the scientific and methodological approach to the innovative and financial modernization of the transport system based on international technology transfer, which in practice will strengthen its competitiveness in the context of EU integration.

To achieve the goal, the following tasks were set:

- to reveal the innovative nature of technology transfer and justify the organizational and economic mechanism of their implementation;
- to systematize the demand factors of the transport system of Ukraine for the transfer of technologies;
- to devise forms and methods of financial and investment support for the transfer of technologies in the transport system of Ukraine.

4. The study materials and methods

The object of our study is the process of innovative and financial modernization of the transport system in Ukraine based on international technology transfer.

The main hypothesis of the research assumes the application of a dynamic approach, in which the development of the transport system is considered as a movement along a trajectory between two points. The entry point is the base state of the transport system, and the output point is its potential, formed at the expense of innovative and analytical support and technology transfer.

The study assumes that the main factor in the demand of the transport system of Ukraine for technology transfer is its export-oriented nature. The simplifications adopted in the study are considering the transport sector as a system – the subject of demand for technology transfer without taking into account the differential features of its subsystems – individual types of transport.

The official statistical reports by the State Statistics Service of Ukraine “Transport of Ukraine – 2021”, “Scientific and innovative activity of Ukraine – 2020”, “Foreign trade of Ukraine – 2021” form the research materials [25]. In the process of research, general scientific methods of analysis and synthesis, systematization, construction of analytical tables, assessment and diagnosis, formalization of trends were used.

In order to determine the competitive position of Ukraine, cross-country comparisons were made based on a number of indicators (Table 1).

Table 1
Indicators for determining competitive position: cross-country comparisons

No. of entry	Indicator	Measurement unit	EU/Country	Years			
				2010	2016	2017	2019
1	Number of employees involved in the implementation of research per 1000 people of the employed population	persons	EU	17.9	...	21.7	...
			Ukraine	9.5	6.0	5.8	5.4
			Slovenia	19.1	22.2	23.3	24.6
			Czech Republic	16.2	19.9	21.1	22.0
2	Share of R&D expenditures in gross domestic product	%	EU	1.92	2.04	2.08	2.14
			Ukraine	0.75	0.48	0.45	0.43
			Germany	2.73	2.73	2.73	3.18
3	Share of the number of researchers in the total number of employees involved in the implementation of research	%	EU	64.0	...	64.9	...
			Ukraine	73.3	65.1	63.0	65.4
			Slovakia	85.5	80.4	80.3	80.4
			Poland	77.8	77.2	78.5	72.4
			Estonia	74.4	74.1	76.6	76.8
4	Share of R&D costs financing in total R&D expenditures	%	EC per sector				
			Entrepreneurial	53.8	...	58.4	58.6
			State	34.8	...	29.2	29.2
			Foreign investors	8.9	...	9.7	9.6
			Ukraine				
			Entrepreneurial	23.8	...	30.1	30.5
			State	49.5	...	44.2	46.3
			Foreign investors	25.8	...	24.4	21.7
			Public sector by country				
			Poland	60.9	...	38.3	35.4
			Spain	46.6	...	38.9	37.6
			Romania	54.4	...	35.9	33.3
			Slovakia	49.6	...	35.5	38.0
5	Share of R&D expenditures by sector of activity in total R&D expenditures	%	EC per sector				
			Entrepreneurial	61.9	66.5	66.5	66.5
			State	12.9	10.8	10.8	10.9
			Higher education	24.2	21.9	21.9	21.8
			Ukraine				
			Entrepreneurial	55.4	58.2	58.5	59.3
			State	38.1	34.5	34.9	34.6
			Higher education	6.5	7.3	6.7	6.1
			Public sector by country				
			Estonia	10.6	11.8	11.4	10.2
			Poland	35.9	2.3	1.9	1.3

The first is the number of employees involved in scientific research (R&D) per 1,000 persons of the employed population (aged 15–70). During 2010–2019, it decreased from 9.5 to 5.4 in Ukraine, while it increased from 17.9 to 21.7 in the EU-28. Unfortunately, Ukraine lags far behind the leading countries in terms of this indicator: Slovenia showed an increase from 19.1 to 24.6, and the Czech Republic – from 16.2 to 22.0.

The second indicator is the share of expenditures on R&D in the gross domestic product. During 2010–2019 in Ukraine, it decreased from 0.75 % to 0.43 %, however, at the EU level, the dynamics are the opposite and are characterized by an increase from 1.92 % to 2.14 %. The best indicators are demonstrated by Germany, with an increase in the analyzed indicator from 2.73 % to 3.12 %.

Ukraine's position is the best in the third indicator – the number of researchers, technicians, and support staff in the total number of employees involved in the implementa-

tion of R&D. During 2010–2019, the share of researchers decreased from 73.3 % to 65.4 %, while in the EU-28 as a whole, it increased from 64.0 % to 64.9 %. The following countries have higher indicators: Slovakia – reduction from 85.5 % to 80.4 %, Poland – reduction from 77.8 % to 72.4 %, Estonia – growth from 74.4 % to 76.8 %.

The fourth indicator – the structure of the financing of R&D expenditures by activity sector – during the analyzed period it is characterized by the following changes. In Ukraine, the share of the business sector increased from 23.8 % to 30.5 %, the share of the public sector decreased from 49.5 % to 46.3 %, and the share of foreign investors decreased from 25.8 % to 21.7 %. The share of the higher education sector, which increased from 0.2 % to 0.3 %, and the private non-profit sector, which is 0.1 %, are insignificant. In the EU-28 countries, the share of the private sector is higher and has increased from 53.8 % to 58.6 %. On the other hand, the specific weight of the public sector and the funds of foreign investors is lower. It shows a corresponding decrease from 34.8 % to 29.2 % and an increase from 8.9 % to 9.6 %. Poland (reduction from 60.9 % to 35.4 %),

Spain (reduction from 46.6 % to 37.6 %), Romania (reduction from 54.4 % to 33.3 %) have the highest indicators of state financing of R&D, Slovakia (decrease from 49.6 % to 38.0 %), Estonia (increase from 44.1 % to 42.8 %).

The fifth indicator is the structure of expenditures for R&D by activity sector. Its main share in Ukraine during 2010–2019 falls on the private sector, it increased from 55.4 % to 59.3 %. The specific weight of the public sector decreased from 38.1 % to 34.6 %, and the higher education sector – from 6.5 % to 6.1 %. In the EU-28 countries, the share of the private sector and the higher education sector are higher, which, respectively, increased from 61.9 % to 66.5 % and decreased from 24.2 % to 21.8 %. The specific weight of the public sector is three times smaller compared to Ukraine and decreased from 12.9 % to 10.9 %. Among all EU countries, the share of the public sector in Ukraine is the maximum, the lowest is in Estonia – a reduction from 10.6 % to 10.2 % and Poland – a reduction from 35.9 % to 1.3 %.

In the Classification of types of economic activity, indicators of the transport system of Ukraine are displayed at the level of section N Transport, warehousing, postal and courier activities. During 2017–2021, the depreciation of fixed assets on it decreased from 50.6 % to 48.1 % and is less than the depreciation rate for the national economy as a whole (Table 2).

Table 2

Dynamics of the fixed assets depreciation indicator, %

Type of economic activity	Code for KVED-2010	2017	2018	2019	2020	2021
Total national economy, incl.	A-U	58.1	55.1	60.6	56.9	58.5
Transport, warehousing, postal and courier activities, incl.	H	50.6	47.6	62.9	54.1	48.1
Land & pipeline Transport	49	46.4	39	62.9	59.2	50.9
Water transport	50	44.2	37.6	33.4	27.5	26.8
Air transport	51	64.1	58.1	60.3	33	52.1

Positive dynamics are also shown by water transport – reduction from 44.2 % to 26.8 %, air transport – from 64.1 % to 52.1 %. The increase in wear of fixed assets of land and pipeline transport is negative – from 46.4 % to 50.9 %. The main means of aviation transport have the greatest wear and tear, which during 2017–2018 exceeded the general economic level. The implementation of innovations in the transport system of Ukraine is, unfortunately, an individual, non-systematic process that proceeds without a targeted innovation and investment policy at the level of enterprises, industry, and the state. The following are identified as the main restraining factors: lack of financial resources for the introduction of innovations at the enterprises of the industry; lack of fundamental, applied scientific research and qualified personnel, etc. They hold back the qualitative transformation of the transport system and slow down the implementation of structural reforms in the industry.

5. Results of research on the development of innovative and financial potential of the transport system of Ukraine based on technology transfer

5.1. The innovative essence of technology transfer and the organizational and economic mechanism of its implementation

The Law of Ukraine “On State Regulation of Activities in the Field of Technology Transfer” [26] defines technology transfer as the transfer formalized by concluding contracts between individuals and/or legal entities. They are bilateral or multilateral in nature, establish, change, terminate, fully or partially transfer property rights and obligations regarding technology and/or its components.

The Ministry of Education and Science of Ukraine (MONU) is the authorized body for the implementation of state policy in the field of technology transfer. It is the central body of executive power that implements state policy in the field of scientific, scientific, technical, and innovative activities. The authorized body for formation and implementation of state policy in the field of technology transfer is the main body in the MONU system – the Department of Innovation and Technology Transfer.

The transport system of Ukraine is a complex entity in which competitive segments are closely intertwined with monopolistic ones. Moreover, innovation processes take place mainly at large transport enterprises, which are either natural monopolies (Ukrzaliznytsia), or have certain signs of monopoly (international trade ports, airports), which are able to accumulate financial resources for technology transfer. Depending on the state of competition in the market and the object of the transfer, coordination of the actions of business entities in the process of concluding agreements can be carried out with or without the permission of the Antimonopoly Committee of Ukraine [27]. A technology transfer agreement can pursue two goals. The first is the production of contract goods by the person who receives such rights (the licensee) and/or by persons authorized by him. The second is the transfer of rights to the technology, according to which the person granting the rights (the licensor) continues to bear the risks associated with the use of this technology by the licensee.

The technology transfer agreement can be 1) reciprocal and 2) non-reciprocal in nature. In case 1), two business entities mutually transfer the rights to certain technologies to each other if they relate to competing technologies or can be used for the production of competing goods by granting a license for use. In case 2) the transfer of rights to the technology is carried out by only one business entity, or two in the case when the licenses do not relate to competing technologies and the production of competing goods.

The objects of transfer are knowledge, technologies, innovations, advanced and business practices. There are the following methods of technology transfer depending on the initiating entity:

1) direct closed (developer of innovations creates promising technological proposals attractive to the market, which are promoted to investors and consumers);

2) reverse closed (consumer of innovations searches for a ready-made technological offer or a developer capable of creating the necessary innovative development);

3) open (the state, institutional structures of the sectoral, national, international level join forces with the help of network web platforms and technology transfer centers to implement joint projects with the active participation of all parties).

Forms of closed technology transfer are patenting, licensing, transfer of know-how, business intelligence, benchmarking, transfer of technical documentation, purchase of equipment or leasing, sale of unpatented inventions. Forms of open technology transfer are joint research and development work, coordination of scientific research, creation of joint ventures, contractual cooperation, etc.

Official statistics of Ukraine do not contain direct information on technology transfer. However, the statistical collection “Foreign Trade of Ukraine - 2021” discloses information about royalties and other services related to the use of intellectual property, including licenses and patents (Table 3).

Ukraine depends on the import of technologies and innovations, as evidenced by the negative values of the export and import balances shown in Table 3. They mainly come from licenses (the share in the end of 2020 and 2021 is 51.39 % and 44.48 %, respectively), as well as franchises and trademarks – 38.55 % and 39.51 %, respectively.

The organizational and economic mechanism of technology transfer is based on a systemic approach and consists of two subsystems:

1) the external subsystem is based on the union of all subjects of the transfer of innovative technologies; ensures the development of their strategic scientific and technical partnership, operational exchange of information between them, creates conditions for the openness of technology transfer and their commercialization;

2) the internal subsystem consists of subsystems of the second level (target, functional, providing), which are designed to form the resources of all participants of the transfer, to optimize their distribution in order to increase the potential for the implementation of the joint project.

The organizational and economic mechanism of technology transfer management should be carried out in the following stages:

1) analysis and consideration of external factors that influence the development of innovative activity;

2) analysis and consideration of internal factors that can influence the choice of entities that are developers, investors, and consumers;

3) organization of interaction between subjects of technology transfer based on the use of Internet platforms and other means of communication;

4) innovative and technological audit of the internal system of transfer entities to increase the future potential of innovative developments;

5) selection and development of a strategy for the commercialization of innovative development in the process of business planning for choosing the optimal form of technology transfer;

6) application of tools to increase the efficiency of implementation of the strategy of transfer and commercialization of open innovative development;

7) the process of implementation of the joint project of transfer of open innovative development, depending on the stage of its readiness according to certain stages. The main ones are nine: development, obtaining experimental evidence, laboratory verification, verification in appropriate conditions, demonstration of the prototype in the real environment and in the operational process, final testing, transfer to production;

8) summarizing the results of the implementation of the open innovation development transfer project: development (innovative activity of the enterprise, innovative competences of personnel, international partnership), strengthening of competitiveness and positioning in new sales markets, obtaining an economic effect.

5.2. Factors of demand of the transport system of Ukraine for technology transfer

The transport system of Ukraine has significant export potential. The dynamics of the export/import balance of transport services during 2016–2019 increased from USD 4.3 billion to USD 7.55 billion, and in 2021 it decreased to USD 2.9 billion (Fig. 1).

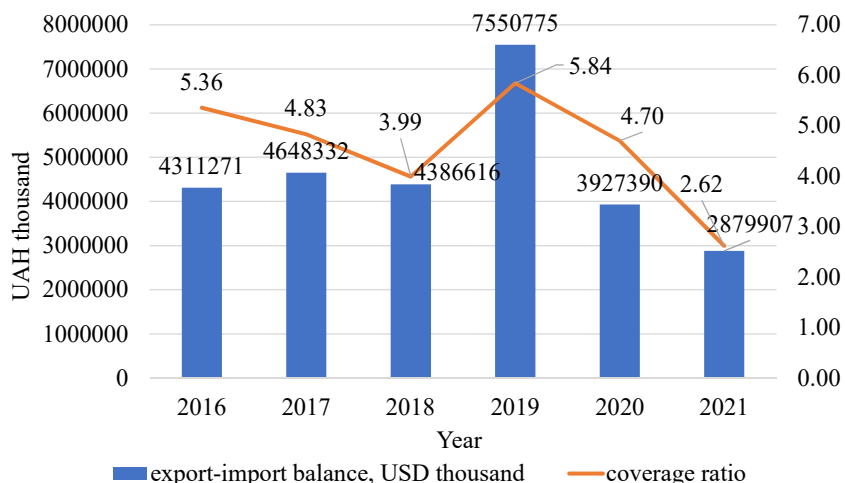


Fig. 1. Dynamics of the export/import balance of transport services and the export/import coverage ratio during 2016–2021

At the beginning of the analyzed period, the export-import coverage ratio was 5.36 times, during 2019–2021, its value decreased from 5.84 to 2.62. That is, in the specified period, there was a deterioration of both the absolute and relative external competitiveness of the transport system of Ukraine. The dynamics of export volumes of transport services by types of transport according to the data of 2016–2021 (Table 4) are formalized by trend functions based on the natural values of the input variables. According to the forks of transport, they are as follows: marine and other – a parabola with branches up (reduction-growth), air, pipeline and together – a parabola with branches down (growth-reduction), railroad – a decreasing straight line, automobile – an increasing straight line.

Thus, during the analyzed period, the external competitiveness of air, rail, and pipeline transport services deteriorated. Reengineering of business processes of transport services is proposed to be carried out on the basis of technology transfer.

During the last decade, the development of the transport and logistics sector of Ukraine was significantly influenced by a number of factors designed to adapt to consumer expectations and maintain competitiveness. The main ones are the growth of international trade, accelerated digitalization, the development

Indicators of exports, imports, royalties, and other services related to the use of intellectual property in Ukraine

Type of services	Export, USD thousand		Import, USD thousand		Balance of exports and imports			
	2020	2021	2020	2021	USD thousand		structure, %	
					2020	2021	2020	2021
Royalties and other services related to the use of intellectual property, of which	94,931	61,775	540,160	625,814	-445,229	-564,039	100	100
Franchise & trademarks	7,728	9,071	179,375	231,944	-171,647	-222,873	38.55	39.51
Licenses	44,202	40,542	272,998	291,444	-228,796	-250,901	51.39	44.48
Patents	37,243	3,838	539	739	36,704	3,099	-8.24	-0.55
Other royalties	5,758	8,323	87,248	101,687	-81,490	-93,364	18.30	16.55

Table 3

of e-commerce, the introduction of the latest information technologies (artificial intelligence, the Internet of Things, blockchain). On the basis of artificial intelligence, integrated transport systems (ITC): “personnel - transport infrastructure - vehicles” are being implemented. They make it possible to regulate traffic flows at a higher level, ensure the interaction of process partici-

pants, transfer and exchange of information with a higher level of security in real time. On the basis of ITS, new generation navigation systems are created and implemented; cargo transportation regulation systems, video surveillance systems, etc.

The sources of financing of innovative and investment costs of transport enterprises are their own funds (profit and depreciation) and attracted resources. The latter are formed by funds of international financial organizations,

Table 4

Formalization of the dynamics of exports of transport services by modes of transport according to the data of 2016–2021

Mode of transport	Trend formalization	Multiple value of the coefficient of determination R^2	Annual average value	
			USD thousand	Structure, %
Marine	$y=12457x^2-92046x+735849$	0.6126	602,618	10.19
Air	$y=-50330x^2+356358x+593322$	0.3752	1,077,244	18.21
Railway	$y=-30312x+614354$	0.7362	508,263	8.59
Automobile	$y=31691x+207099$	0.9482	318,017	5.38
Pipeline	$y=-346779x^2+2E+06x+218540$	0.4403	3,099,948	52.41
Others	$y=9602,1x^2-46933x+296591$	0.954	309,049	5.22
Total	$y=-373299x^2+3E+06x+3E+06$	0.4069	5,915,139	100.0

The latest transport solutions include:

- development of intermodal, multimodal and combined transportation. Consecutive intermodal transportation of goods is provided by two or more modes of transport in one and the same transport unit without overloading the cargo itself when changing the mode of transport. In case of multimodal (combined, mixed) transportation of goods or passengers, or both, two or more types of transport are used together;

- creation and development of high-speed modes of transport (including passenger trains), high-speed highways;
- development of transport logistics.

The latest technical solutions include:

- creation of new generations of equipment and technologies in transport engineering (with automatic control, electric cars, electric planes, electric trains, etc.);

- increasing the level of environmental friendliness and safety of vehicles;

- development of international transport corridors (ITC) as a collection of various types of transport, which provide significant transportation of goods and passengers in the directions of their greatest concentration;

- modernization of MTK infrastructure;

- completion of electrification of Ukrainian railroads.

Modern technologies are represented by new innovative, informational, and transport solutions in transport, technical re-equipment of transport enterprises, modernization of road and transport economy, etc. They generate innovative structural changes and form a new, progressive business model of the functioning of the transport system of Ukraine, make significant changes in the business processes of transporting goods and passengers.

5. 3. Financial and investment support for technology transfer in the transport system of Ukraine

An important factor that determines the possibility of technology transfer is financial and investment support as a constituent element of the financial and investment policy of the state, the transport system of Ukraine, and its individual subjects. It should ensure the creation of the necessary financial resources for: investing in the development of the scientific and technical potential of transport and its infrastructure, rapid and effective introduction of new products, structural and innovative restructuring of the transport system.

the state budget of Ukraine, sectoral extra-budgetary funds, loans from banking institutions and enterprises-customers of innovative developments in the form of targeted financing. The limitation of profit as a source of financing the transfer of technologies is explained, firstly, by its absence due to the unprofitable operation of most enterprises of the transport system; secondly, unwillingness to risk existing own funds to finance risky investments. The Law of Ukraine “On State Regulation of Activities in the Field of Technology Transfer” [26] singles out a specific financing instrument as a targeted subsidy for technology transfer provided by the state. Its amount and distribution according to the terms of provision are included in the financial plan for technology transfer and approved by the commission for organizing the activities of technology parks and other types of innovative structures of the Cabinet of Ministers of Ukraine. The import of technologies financed from budget funds into Ukraine requires approval. Its form is a state examination to prevent the purchase of technologies that are morally obsolete, harmful to the natural environment and/or human health, etc.

The Department of Innovative Activities and Technology Transfer of the National Academy of Sciences of Ukraine approves the import of technologies or their components after receiving an expert opinion in accordance with the procedure determined by the Cabinet of Ministers of Ukraine.

Chapter V of the Law of Ukraine “On State Regulation of Activities in the Field of Technology Transfer” [26] defines the procedure for financial and economic support in the field of technology transfer. Its components are remuneration to the authors of technologies and persons carrying out their transfer (Article 22), use of funds received as a result of the transfer of technologies (Article 23). Article 24 defines special conditions for providing state support and crediting technology transfer in terms of providing state guarantees for repayment of loans from banking institutions, development of technology transfer centers.

6. Discussion of results of the impact of technology transfer on the growth of the innovative and financial potential of the transport system in Ukraine

Our results, represented by the improvement of the scientific and methodological approach to the innovative and financial modernization of the transport system based on the international transfer of technologies, are based on the use of a number of tools formalized by tables and figures. The objects of the used dynamic approach are cross-country comparisons (Table 1), the level of wear of fixed assets in the national economy and its transport system (Table 2), which is characterized by multidirectional trends in its

sub-sectors. The indicators of export, import, royalty balance, and other services related to the use of intellectual property (Table 3) testify to the high dependence of the national economy on the import of technologies and innovations. The disappointing results obtained in the development of the transport system of Ukraine are explained by insufficient attention to the cause-and-effect relationships between international transfers and their financing. The results of the assessment of the dynamics of the balance of export/import of transport services and the coefficient of export-import coverage (Fig. 1) are positive, which demonstrate a high level of external competitiveness of the national transport system, but its reduction is negative. The formalization of the dynamics of the export of transport services by types of transport (Table 4) made it possible to differentiate the situation with the external competitiveness of certain types of transport and the trends of its changes in view of the risks of operation.

In contrast to known publications, study [28] succeeded in justifying the strategies of reforming the transport system of Ukraine on an innovative basis thanks to the consideration of precisely unforeseeable risk factors and macro-risks: loss of national sovereignty, economic independence, competitiveness of the national economy and its transport system.

The use of innovative technologies in the transport system on the market should be based on a systemic approach [29], taking into account the necessary level of sustainability of its enterprises. Their implementation at certain stages under the conditions of the variability of the external environment will allow to strengthen competitive advantages and increase the efficiency of the production and economic activity of transport enterprises.

The features of the proposed solutions, unlike the existing ones, take into account the presence of martial law and military operations, as well as the need to restore the destroyed transport infrastructure. It is expedient to put the import of modern technologies as its basis, to take measures of state policy to ensure the ability of the transport industry to serve domestic transportation in order to restore the economy and ensure its further growth.

Our solutions on the modernization of interstate and transnational transport corridors, preservation of the status of a transit state solve in practice the problem of strengthening the competitiveness of the national economy under the conditions of integration into the EU.

The principles of the state transport policy of Ukraine should be the integration of the national transport system into the European one, its balance by types of transport, the quality and safety of the transport process, the introduction of innovative energy-saving and ecological technologies.

The shortcomings of the study are due to the different competitive status of certain types of transport under the conditions of martial law. The limitations of this study are related to the lack of official statistics on international technology transfer by type of economic activity. Therefore, the results should be treated with caution and the possibility of adaptation should be provided when attempting practical use for making management decisions at the level of individual economic entities, taking into account their differential features. In the future, it is necessary to take into account our results for the justification of strategies for the development of the transport system at the level of its sub-sectors. The development of this study consists in substantiating

proposals for the use of the transport system for the needs of the military and civilian economy.

7. Conclusions

1. The innovative essence of technology transfer is revealed, and the organizational and economic mechanism of its implementation is substantiated. An assessment of the competitive position of Ukraine in the market of scientific research works in relation to the EU-28 and individual countries has been carried out. The country's position is weak according to the following indicators: the number of employees involved in the performance of scientific research works (R&D) per 1,000 persons of the employed population, the share of R&D expenses in the gross domestic product. Ukraine's competitive position in terms of the number of researchers in the total number of employees involved in the implementation of the R&D is the best. Compared to EU, the share of the private sector is higher in the structure of financing of R&D expenditures in the EU-28 countries, and the share of the public sector and funds of foreign investors is lower. Among all EU countries, the share of public sector R&D expenditures in Ukraine is the largest. Intensification of entrepreneurial activity on the basis of international technology transfer is proposed as a tool to eliminate weak competitive positions of the country in the R&D market.

2. The demand factors of the transport system of Ukraine for the transfer of technologies have been systematized. The main ones are high physical and moral wear of fixed assets; non-systematic and unmanaged innovation implementation process; lack of financial resources for the introduction of innovations at the enterprises of the industry. Also important are the lack of fundamental and lack of applied scientific research aimed at qualitative transformations of the transport system; the slow nature of carrying out structural reforms in the industry.

3. Forms and methods of financial and investment support for technology transfer in the transport system of Ukraine have been developed. Funds from international financial organizations, sectoral extrabudgetary funds, targeted state subsidies, state guarantees for bank loans have been defined as promising instruments for financial and investment support of technology transfer in the transport system of Ukraine.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

The manuscript has associated data in the data warehouse.

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