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SCHOLARLY RESEARCH AND APPLIED APPROACH TO THE INTERDEPENDENCE OF MANUFACTURE AND TRANSPORTATION OF PRODUCTS BASED ON INTERMODALITY AND MULTIMODALITY

Introduction. *The integration processes of the transport system are an important factor in the economic development of Ukraine in conditions of increased competition for transit cargo flows. Therefore, it is necessary to develop multimodal transportation of products to ensure the competitiveness of Ukraine in the international transport market.*

Problem Statement. *In the modern conditions of the development of the transport system of Ukraine, there have arisen theoretical and applied problems related to determining the most appropriate means for hybrid cargo transportation.*

Purpose. *This study is aimed at identifying the interdependence of the sphere of manufacture and transportation of products in order to determine and justify the most efficient means of organization of intermodal and multimodal cargo transportation.*

Material and Methods. *The review of existing scientific developments is based on systematic approach and comparative historical analysis of the transport economy, given the economic, geographical, and geopolitical position of Ukraine. The verification and falsification methods, as well as the economic and mathematical analysis and modeling have been used to substantiate the scholarly and applied approach.*

Results. *The theoretical and practical problems of the transport economy development have been analyzed. The trends in the development of cargo transportation by various means of transport have been identified. The dependence of the products sold (goods, services) on the products transported by means of transport has been simulated. The types of activities, which require transport services and are significant for the national economy have been analyzed. The choice of the most appropriate means of transport for cargo transportation based on intermodality and multimodality, in particular rail, sea, and inland water transport, has been justified.*

Conclusions. *The scholarly and applied approach has been proposed to identify the interdependence of manufacture, intermodal and multimodal cargo transportation of products. It can be used to increase the competitive advantages of Ukraine's transit potential.*

Keywords: hybrid cargo transportation, intermodal transportation, multimodal transportation, state regulation, correlation and regression analysis, rail transport, sea transport, and inland water transport.

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In the context of globalization transformations, an important factor in the country's economic development is to ensure the integration processes of the transport system, especially in the context of multimodal cargo transportation. The favorable geographical position of Ukraine en route to transit cargo flows, the presence of a developed network of railways, as well as ice-free Black Sea ports, highways determine the transit potential and form a key role in ensuring interstate transport and economic relations. In the transit of products of all types of transport (except pipeline), railway transport occupies a leading place and provides more than 80% of the total cargo turnover. The decline in the interstate cargo flows, as well as changes in cargo routes, leads to increased interindustry and interstate competition for transit cargo flows. This makes the development of multimodal transport of products one of the determining factors for ensuring the country's competitiveness in the international transport market. In such conditions, there is a need to conduct research on the processes of improving multimodal and intermodal cargo transportation using statistical research methods that are important, timely and require quick solutions for practice. The identification of the main trend direction allows us to justify the forecast economic phenomena of the intensity and efficiency of the use of means of transport in the organization of intermodal and multimodal cargo transportation.

THEORETICAL AND PRACTICAL PROBLEMS OF THE TRANSPORT ECONOMY DEVELOPMENT

The development of multimodal transport of products has recently become extremely important and is influenced by the strengthening of globalization, which is an important factor in ensuring the integration of the Ukrainian economy into the world economy. Existing studies have proved that the achievement of an effective and safe supply chain management system in the context of increasing global trade processes is necessary on the basis of intermodal and multimodal transport [1]. Especially now, when the trans-European and transcontinental transport routes are developing rapidly, it is necessary to develop multimodal chain modules for modeling container traffic, in particular within the Dutch strategic freight transport model Bas Goed [2], real-time decision support systems based on a hybrid approach to modeling and optimization for intermodal transport [3] in order to improve the reliability of intermodal transport to increase its use and minimize the negative externalities of cargo transport. In particular, Wolfinger D. et al. [4] tried to solve the problem of planning the transport of products over long distances by providing a mathematical algorithm that allows us to find a set of possible routes using intermodal and multimodal transport, taking into account the minimization of transport costs and transshipment costs. Studies of the willingness of shippers to delegate control over means of transport by determining their relationship to synchromodal transport services have allowed Khakdaman M., Rezaei J., & Tavasszy L. A. [5] to determine that two-thirds of shippers are willing to transfer control of transportation to service providers in order to improve productivity. Equally important is the structure for assessing the sustainability of multimodal networks, since synchromodal transport provides for flexible switching between different means of transport in real time, taking into account the relevant logistic information [6]. This allows for more efficient use of vehicles and helps plan maintenance by prioritizing critical infrastructure. Based on the results of the use of scenario analysis of intermodal transport in the context of service network design models on the example of Belgium [7], models for the design of a service network for cargo systems based on consolidation have been developed. They emphasize the high cost of rail transport and the economic benefits of inland waterway transport.

Taking into account the peculiarities of the geopolitical situation of Ukraine, in order to increase its attractiveness for participation in the world routes of intermodal and multimodal trans-

port, leading modern specialists were engaged in the development, implementation and adaptation of information computer systems in transport [7—8], which made it possible to determine the information support of transport, the importance and application of information systems in the work of transport, transport routes, and supply chain management. The solution of problematic issues of modern information control and diagnostic systems of vehicles [9], information support of the organized system of international transport communications [10] allows increasing the competitiveness of vehicles by expanding the functionality of information systems, but the use of leading modern information systems does not take a leading role in the management of traffic flows in Ukraine.

The problems of increasing the competitiveness of the transport complex in the international cargo transport market and the implementation of the transit potential of Ukraine were studied by Mikhailichenko K. M. & Belashov E. V. [11]. The research has identified the causes of a rapid decline in transit traffic through the Ukrainian territory, suggested directions and measures of government policy, the implementation of which contributes to the restoration of the transit potential of Ukraine. Given the focus on the European integration of Ukraine and the need to involve ports in the international TEN-T network, Palyvoda O. et al. [12] carried out a comprehensive assessment of the investment attractiveness of seaports using the Saaty method and the method of calculating the integral indicator of the investment attractiveness of seaports in order to use it to increase the efficiency of attracting investments in their development. Studies of the chain of obstacles to the implementation of international cargo transportation through non-tariff instruments of foreign trade policy made it possible to identify strategic priorities for the development of the transit potential of Ukraine [13], and based on the analysis of the state of the transport system of Ukraine, the main factors of influence and problems [14], the main promising directions for improving the efficiency of international transport management have been clarified.

It should also be noted that some authors use mathematical modeling in the study of transport systems, in particular Gasnikov A. V. et al. [15] generalized mathematical models for predicting traffic congestion, choosing the optimal topology of the transport network, approaches to modeling transport systems based on graph theory. The studies of approaches to predicting traffic flows for certain road networks based on the use of the ARIMA space-time model [16], the additive seasonal vector autoregressive model taking into account spatial dependence [17], space-time correlations, regression analysis, the Box-Jenkins model and its analog for time series, intelligent analysis methods, in particular the method of reference vectors and neural networks [18—19] allow predicting the speed and volume of cargo traffic of multimodal and intermodal transport, creating a scientific and practical basis.

However, in the current conditions of development of the transport system of Ukraine, there are a number of problems of a theoretical and applied nature that require solutions through scientific justification and the development of appropriate methodological approaches and practical recommendations. Therefore, this study is aimed at identifying the interdependence of the sphere of production and transportation of products to determine and justify the most efficient means of transport in the organization of intermodal and multimodal cargo transportation.

The paper presents an overview of existing scientific developments. It is based on a systematic approach and comparative historical analysis with the use of the factor method for the development of the transport economy. Special attention is paid to the multimodal transport of products and the strengthening of the globalization processes. The economic, geographical, and geopolitical position of Ukraine is taken into account. The scholarly and applied approach to identifying the interdependence of the sphere of production and transportation of products has been substantia-

ted to determine and justify the most efficient means of transport in the organization of intermodal and multimodal cargo transportation. The methods of verification and falsification, economic and mathematical analysis and modeling of the dependence of the products sold (goods, services) and cargo turnover on the goods transported by various means of transport by economic entities of economic activities were used.

TRENDS IN THE DEVELOPMENT OF CARGO TRANSPORTATION BY VARIOUS MEANS OF TRANSPORT

The annual cargo transportation by automobile transport in Ukraine is growing (Table 1 and Table 2) and currently occupy the largest share in the total volume of traffic (72.65% (1147049.6 thousand tons), in 2019; 66.38% (1252390.3 thousand

Table 1. **Cargo Shipments by Type of Transport in Ukraine**

Years	Cargo transported by type of transport, thousand tons					
	Rail transport	Sea transport	Inland water transport	Automobile transport	Air transport	Pipeline transport
2011	469308.1	4145.6	5720.9	1252390.3	92.1	154971.2
2012	457454.5	3457.5	4294.7	1259697.7	122.6	128439.8
2013	443601.5	3428.1	2840.5	1260767.5	99.2	125941.1
2014	386276.5	2805.3	3144.8	1131312.7	78.6	99679.5
2015	349994.8	3291.6	3155.5	1020604.0	69.1	97231.5
2016	343433.5	3032.5	3641.8	1085663.4	74.3	106729.2
2017	339550.5	2253.1	3640.2	1121673.6	82.8	114810.4
2018	322342.1	1892.0	3698.0	1205530.8	99.1	109418.2
2019	312938.9	2120.3	3990.2	1147049.6	92.6	112656.4

Source: Developed by the authors on the basis of data [20].

Table 2. **Structure of the Transported Products by Type of Transport in Ukraine**

Years	Cargo transported by type of transport, thousand tons					
	Rail transport	Sea transport	Inland water transport	Automobile transport	Air transport	Pipeline transport
2011	24.88	0.22	0.30	66.38	0.00	8.21
2012	24.68	0.19	0.23	67.96	0.01	6.93
2013	24.15	0.19	0.15	68.64	0.01	6.86
2014	23.80	0.17	0.19	69.69	0.00	6.14
2015	23.74	0.22	0.21	69.22	0.00	6.59
2016	22.26	0.20	0.24	70.38	0.00	6.92
2017	21.46	0.14	0.23	70.90	0.01	7.26
2018	19.62	0.12	0.23	73.37	0.01	6.66
2019	19.82	0.13	0.25	72.65	0.01	7.14

Source: Calculated by the authors.

tons), in 2011). Cargo transportation by rail in 2019 in the total structure of the transported products is 19.82% (312938.9 thousand tons), but each year it gradually decreases due to significantly high tariffs for services. It should be noted that the experience of the leading countries (USA, EU, and China) has shown that rail transport is the main carrier that can provide significant transit traffic, in particular, via multimodal transport.

The cargo transportation by sea and inland water transport decreases annually and in 2019 amounted to 2120.3 thousand tons and 3990.2 thousand tons, respectively, so their share in the overall structure also tended to decrease and in 2019, and was 0.13% and 0.25%, respectively. The pipeline transports about 6—8% of the total cargo. The smallest cargo transportation is carried out by air transport and accounts for up to 0.01% of the total structure of cargo transportation, which can be explained by the high cost of such transportation.

From the point of view of the subjects of various spheres of economic activity, transport is usually considered as a set of technical means for the transportation of products and provides uninterrupted and timely satisfaction of the needs of transportation in the national economy. Therefore, according to the authors, it is necessary to study the impact of the products (goods, services) produced by business entities for various types of economic activity on the products (works, services) sold and cargo turnover by various means of transport. For the analysis, we selected the spheres of economic activity that are most in need of cargo transportation by various means of transport (Tables 3 and Table 4).

During the analyzed period, the largest cargo turnover is observed in railway transport whose share in the total cargo turnover is about 60%, but it has an annual downward trend. Thus, in 2014, the cargo turnover of railway transport is 62.55%, but in 2019 only 53.65%. Also, a significant cargo turnover is observed by the pipeline transport. From 2014 to 2019, it increased by 6.36% and accounts for 30.84% of the total cargo turnover by all means of transport. The cargo turnover of automobile transport in the total volume for all means of transport during the analyzed period is only about 10—12%, but in 2019 its share increased to 14.43%. The lowest cargo turnover is observed on water and air transport and amounted to 1.00% and 0.09%, respectively, in 2019. It should be noted that the experience of the leading countries (USA, EU, and China) has shown that rail transport is the main carrier that can provide significant transit traffic over long distances, in particular, via multimodal transport.

Table 3. **The Products (Goods, Services) Manufactured by Economic Entities, by Type of Economic Activity in Ukraine**

Years	Products (goods, services) produced, mln. XDR		
	Agriculture, forestry and fisheries	Industry	Construction
2013	15900.61	102347.30	11904.85
2014	12559.34	58399.05	6958.19
2015	12516.56	48262.49	4273.61
2016	13032.63	52699.10	4950.47
2017	13144.06	61741.26	5756.78
2018	15998.87	72640.48	7342.26

Source: Developed by the authors on the basis of data [20] taking into account the official exchange rate of the hryvnia to the special drawing rights [21].

SIMULATION OF THE DEPENDENCE OF THE PRODUCTS SOLD (GOODS, SERVICES) ON THE PRODUCTS TRANSPORTED BY MEANS OF TRANSPORT

The method of statistical equations of dependencies allows us to justify the predicted economic phenomena of the intensity and efficiency of the use of means of transport in the organization of intermodal and multimodal cargo transport. Empirical studies have shown that the relationship between the products sold (goods, services) by business entities for various types of economic activity and the products transported by means of transport, in general, show positive and negative, but varying degrees of correlation dependence (Table 5).

Table 4. **The Products Sold (Works, Services) and Cargo Turnover by Type of Transport in Ukraine**

Years	Products sold (works, services), mln. XDR	Cargo turnover, million tons/km					
		All types of transport	Including:				
			Rail transport	Automobile transport	Inland water transport	Pipeline transport	Air transport
2013	18178.86	379045	224017.8	40487.2	4615.2	109651.8	273
2014	9764.86	335151.7	209634.3	37764.2	5462.3	82050.9	240
2015	9682.63	315341.8	194321.6	34431.1	5434.1	80944.1	210.9
2016	10947.71	323473.9	187215.6	37654.9	3998.6	94378.9	225.9
2017	12012.85	343057.1	191914.1	41178.8	4257.1	105434.4	272.7
2018	14439.56	331856.2	186344.1	42569.5	3363	99239.9	339.7
2019	18441.08	338962.5	181844.7	48906.3	3387.8	104528.1	295.6

Source: Developed by the authors on the basis of data [20] given the official exchange rate of the hryvnia to the special drawing rights [21].

Table 5. **Correlation Dependence of the Products Sold (Goods, Services) on the Products Shipments by Type of Transport**

		VPS	RT	MT	PT	AutoT	AviaT	TT
Products sold (VPS)		1.0						
Type of transport	railway (RT)	–0.8662	1.0					
	marine (MT)	–0.8522	0.7319	1.0				
	inland water (IWT)	0.9384	–0.9033	–0.8103	1.0			
	automobile (AutoT)	–0.0014	0.4537	–0.1789	–0.1571	1.0		
	air (AirT)	0.3130	0.1587	–0.4146	0.1068	0.9338	1.0	
	pipeline (PT)	0.0965	0.3960	–0.0393	–0.0532	0.7949	0.7598	1.0

0.00–0.30	very weak		0.71–0.90	high
0.31–0.50	weak		0.91–0.99	very high
0.51–0.70	moderate		1.0	functional relationship

Source: Calculated by the authors.

The strongest positive correlation is observed between the products sold and the products transported by inland water transport (0.9384), as well as between the products transported by air and automobile transport (0.9338). A high positive correlation is observed between the cargo transported by sea and rail (0.7319), pipeline and road transport (0.7949), and pipeline and air transport (0.7598). A high negative correlation, that is, an increase in one variable leads to a decrease in the studied parameter, between the products sold and the products transported by rail (–0.8662) and the products transported by sea (–0.8522), as well as the products transported by inland water and rail (–0.9033) and sea (–0.8103) transport. There is a weak and very weak correlation between the other studied indicators. The data obtained provide for the possibility of further research. Using the statistical method of multiple regression, a multivariate econometric model of the dependence of the products sold (goods, services) on the products transported by means of transport is constructed, expressed in a 6-dimensional plane and has the form of the dependence of the products sold (goods, services) on the goods transported by means of transport:

$$VPS = 909138.45 - 2.91 \cdot RT + 1.34 \cdot MT + 35.28 \cdot IWT - 0.56 \cdot AutoT + 6010.59 \cdot AirT + 4.81 \cdot PT. \quad (1)$$

The equation shows that the slope of the plane in the direction of the products transported by rail (–2.91) and road (–0.56) represents the negative sensitivity of the products sold, while the slope of the plane in the direction of the products transported by sea (+1.34), inland water (+35.28), air transport (+6010.59), and pipeline (+4.81) represents the positive sensitivity of the products sold. At the same time, the reliability of the obtained model (the coefficient of determination) is 1.0, that is, the change in the VPS value is completely due to the corresponding indicators, the standard error is 0. The significance of the *F* and *p* values is 0, and the sign of the free term (constant) of the equation does not change when moving from the column "lower 99%" to the column "upper 99%". All this indicates the statistical significance of the constructed econometric model.

A multi-factor econometric model of the products sold (goods, services) is based on the production function of knowledge. It makes it possible to study the absolute and relative influence of factors on the products sold (goods, services), to determine the potential reserves for their increase (decrease), as well as to evaluate them using comparative analysis. That is, for example:

- if the products transported by rail increases by 1%, with other indicators unchanged, there is a decrease in the products sold by 2.64%; and vice versa, if the cargo transportation decreases by 1%, there is an increase in the products sold;
- an increase in the products transported by sea by 1%, with other indicators unchanged, leads to an increase in the products sold by 0.03%; and vice versa, with a decrease in the cargo transportation by 1%, there is a decrease in the products sold;
- with an increase in the products transported by inland water transport by 1%, according to other unchanged indicators, there is a decrease in the products sold by 0.18%; and vice versa, with a decrease in the cargo transportation by 1%, there is an increase in the products sold;
- if the products transported by road increases by 1%, with other factors unchanged, there is a decrease in the products sold by 0.13%; and vice versa, if the cargo transportation decreases by 1%, there is an increase in the products sold;
- an increase in the cargo transported by air transport by 1%, with other indicators unchanged, leads to an increase in the products sold by 0.57%; and vice versa, in the case of a decrease in the cargo transportation by 1%, there is a decrease in the products sold;
- with an increase in the cargo transported through the pipeline by 1%, with other indicators unchanged, there is an increase in the products sold by 1.31%; and vice versa, with a decrease in the cargo transportation by 1%, there is a decrease in the products sold.

The empirical studies have demonstrated that the relationship between the products (goods, services) of economic entities by type of economic activity (agriculture, forestry and fisheries; industry and construction) and the products transported by type of transport, in general, shows a positive and negative, but varying degrees of correlation (Table 6).

It has been found that the products transported by inland water transport (0.9361) has the strongest positive correlation with the products manufactured; the products transported by rail (–0.8602) and sea transport (–0.8933) has a very weak positive correlation with the products transported by road (0.0267) and the products transported by pipeline (–0.0864)); there is a weak correlation between the products manufactured and the products transported by air (–0,3383). The data obtained indicate the possibility of further research.

JUSTIFICATION OF THE MOST APPROPRIATE MODES OF TRANSPORT FOR CARGO TRANSPORTATION BASED ON INTERMODALITY AND MULTIMODALITY

Using the statistical method of multiple regression, econometric models of the dependence of the products transported by type of transport on the products (goods, services) of economic entities by type of economic activity are constructed and have the form of:

1. The regression model of the dependence of the products transported by rail on the products (goods, services) of economic entities by type of economic activity:

$$RT = 468774 - 0.0412 \cdot PV. \quad (2)$$

The degree of reliability of the constructed model is 0.7400, that is, the change in the cargo transported by road transport by 74.00% is due to the products of business entities by type of economic activity, while other factors account for 36.00% of the change. The standard error of the constructed equation is 25020.63, which is 5.64—8.00% in percentage terms of the products transported by the specified transport. Since the correlation coefficient and the correlation index are almost the same, that is, the difference between these indicators of the strength of relationship is 0.01; this indicates that the choice of the type of equation to characterize the relationship is correct. The parameter indicates that a change in the size of the deviation from the *PV* unit per unit leads to a change in the size of the deviation of the products transported by rail by 0.0412. $b = -0.0412$ The significance of F is 0.0130 and the p-value is 0.00002, while the sign of the free term (constant) of the equation does not change when moving from the column "lower 95%" to the column "upper 95%". All this indicates the statistical significance of the constructed econometric model with 95% reliability.

Figure 1 shows the actual and calculated values of the constructed regression model, as well as the error limits of the model.

2. The regression model of the dependence of the products transported by sea on the products

Table 6. **Correlation Dependence of the Transported Products (by Type of Transport) on the Products (Goods, Services) of Economic Entities (by Type of Economic Activity)**

Cargo transported by type of transport					
Rail transport	Sea transport	Inland water transport	Automobile transport	Air transport	Pipeline transport
–0.8602	–0.8933	0.9361	–0.0267	0.3383	0.0864

Source: Calculated by the authors.

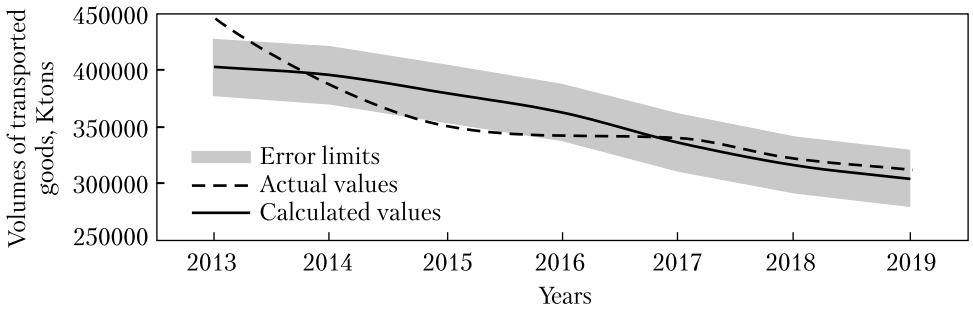

Fig. 1. Actual and calculated values of the products transported by rail
Source: Calculated by the authors.

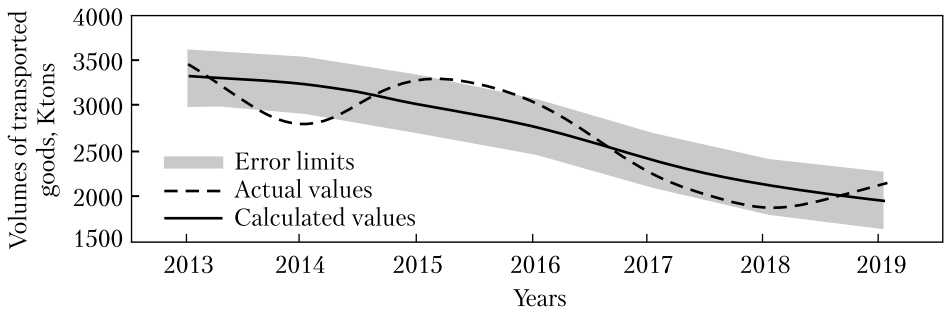

Fig. 2. Actual and calculated values of the cargo transported by sea
Source: Calculated by the authors.

(goods, services) of economic entities by type of economic activity:

$$MT = 4256.26 - 0.0006 \cdot PV. \quad (3)$$

The degree of reliability of the constructed model is 0.7980, that is, the change in the cargo transported by sea by 79.80% is due to the products of business entities by type of economic activity, while other factors account for 20.20% of the change. The standard error of the constructed equation is 297.3907, which is 8.68—15.72% as a percentage of the products transported by the specified transport. Since the correlation coefficient and the correlation index are almost the same, that is, the difference between these indicators of the strength of relationship is 0.01; this indicates that the choice of the type of equation to characterize the relationship is correct. The parameter indicates that a change in the size of the deviation from the *PV* unit per unit leads to a change in the size of the deviation of the products transported by rail by 0.0.0006. $b = -0.0006$ The significance of F is 0.0067 and the p-value is 0.00009, while the sign of the free term (constant) of the equation does not change when moving from the column "lower 99%" to the column "upper 99%". All this indicates the statistical significance of the constructed econometric model with 99% reliability. Figure 2 shows the actual and calculated values of the constructed regression model, as well as the error limits of the model.

3. The regression model of the dependence of the products transported by inland water transport on the products (goods, services) of economic entities by type of economic activity:

$$IWT = 2347.09 + 0.0004 \cdot PV. \quad (4)$$

The degree of reliability of the constructed model is 0.8764, that is, the change in the cargo transported by sea by 87.64% is due to the pro-

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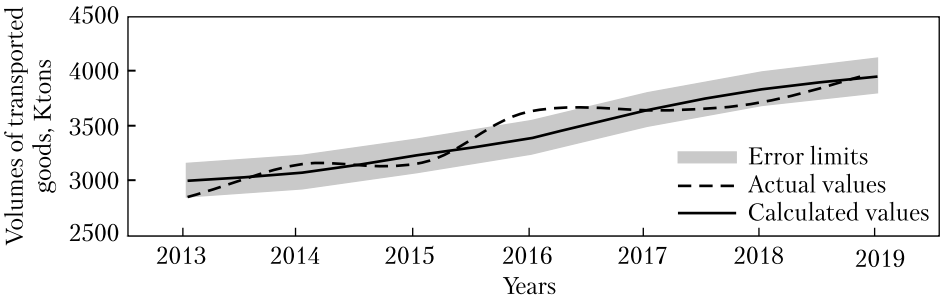

Fig. 3. Actual and calculated values of the products transported by inland water transport
Source: Calculated by the authors.

ducts of business entities by type of economic activity, while other factors account for 12.36% of the change. The standard error of the constructed equation is 155.4675, which is 3.90—5.47% as a percentage of the products transported by the specified transport. Since the correlation coefficient and the correlation index are almost the same, that is, the difference between these indicators of the strength of relationship is 0.01; this indicates that the choice of the type of equation to characterize the relationship is correct. The parameter indicates that a change in the size of the deviation from the *PV* unit per unit leads to a change in the size of the deviation of the products transported by rail by 0.0.0004. $b = 0.0004$ The significance of F is 0.0019 and the p-value is 0.00007, while the sign of the free term (constant) of the equation does not change when moving from the column "lower 99%" to the column "upper 99%". All this indicates the statistical significance of the constructed econometric model with 99% reliability. Figure 3 shows the actual and calculated values of the constructed regression model, as well as the error limits of the model.

4. The regression model of the dependence of the products transported by road transport on the products (goods, services) of economic entities by type of economic activity:

$$AutoT = 1132892.86 + 0.0022 \cdot PV. \quad (5)$$

The degree of reliability of the constructed model is 0.0007, that is, the change in the cargo transported by road transport by 0.07% is due to the products of business entities by type of economic activity, while other factors account for 99.93% of the change.

5. The regression model of the dependence of the products transported by air transport on the products (goods, services) of economic entities by type of economic activity:

$$AirT = 73.26 + 0.000004 \cdot PV. \quad (6)$$

The degree of reliability of the constructed model is 0.1145, that is, the change in the cargo transported by road transport by 11.45% is due to the products of business entities by type of economic activity, while other factors account for 88.55% of the change.

6. The regression model of the dependence of the products transported by pipeline transport on the products (goods, services) of economic entities by type of economic activity:

$$PT = 107064 + 0.00089 \cdot PV. \quad (7)$$

The degree of reliability of the constructed model is 0.0075, that is, the change in the cargo transported by road transport by 0.75% is due to the products of business entities by type of economic activity, while other factors account for 99.25% of the change.

The conducted studies allow us to use models for further research only with a degree of confidence of more than 50%, that is, the models are built for the cargo transported by rail, sea and inland water transport. Other models are unreliable. The constructed econometric models are uni-

variate and dynamic, since the influence of the products (goods, services) of economic entities by type of economic activity (agriculture, forestry and fisheries; industry and construction) on the products transported by various means of transport is considered, and the study of the relationship of development in time is a necessary factor of change. Given the significant quality of the regression equation, it can be used for practical purposes to describe the dependence and forecast the cargo transportation by rail, sea and inland water transport.

The analysis of the volume and structure of cargo transported by various means of transport, as well as cargo turnover, has allowed us to identify the most used types of transport, in particular, rail, pipeline and road. Considering that from the point of view of subjects of various spheres of economic activity, transport is usually considered as a complex of technical means for the transportation of products and ensures uninterrupted and timely satisfaction of the needs of the national economy in transportation, for the analysis, the spheres of economic activity that are most in need of cargo transportation by various means of transport have been selected. A scientific and applied approach was proposed to determine the most appropriate means of transport for cargo transportation on the basis of intermodality and multimodality, which is based on the use of methods of economic and mathematical analysis and modeling of the dependence of the products sold (goods, services) and cargo turnover on the products transported by various types of transport by economic entities of economic activities, which allows identifying the most appropriate means of transport to improve the efficiency of functioning and competitive advantages of the transport system of Ukraine. Based on the conducted diagnostics, monitoring and modeling of the impact of the products (goods, services) produced by economic entities of various types of economic activity on the products (works, services) sold and cargo turnover of various types of transport, such most appropriate types of transport as rail, sea and inland water have been identified. Given the significant quality of the study, the results can be used for practical purposes to predict the cargo transportation by the most appropriate means of transport, such as rail, sea and river. Thus, the study has given grounds to assert the need to develop in Ukraine the transportation of goods by waterways in Ukraine to stimulate the development of water transport and increase the competitive advantages of using multimodal and intermodal cargo transportation through the territory of Ukraine, which contributes to the integration of the transport system of Ukraine into the world.

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НАУКОВО-ПРИКЛАДНИЙ ПІДХІД ДО ВЗАЄМОЗАЛЕЖНОСТІ ВИРОБНИЦТВА Й ТРАНСПОРТУВАННЯ ПРОДУКЦІЇ НА ОСНОВІ ІНТЕРМОДАЛЬНОСТІ ТА МУЛЬТИМОДАЛЬНОСТІ

Вступ. Інтеграційні процеси транспортної системи є важливим чинником економічного розвитку України в умовах посилення конкуренції за транзитні вантажопотоки. Розвиток змішаних перевезень вантажів є одним з основних шляхів забезпечення конкурентоспроможності України на міжнародному транспортному ринку.

Проблематика. У сучасних умовах розвитку транспортної системи України виникає проблема теоретичного та прикладного характеру щодо визначення найбільш доцільних видів транспорту для здійснення змішаних перевезень вантажів.

Мета. Виявлення взаємозалежності сфери виробництва та транспортування продукції для визначення та обґрунтування найбільш ефективних видів транспорту при організації інтермодальних і мультимодальних перевезень вантажів.

Матеріали й методи. Огляд наявних наукових досліджень в галузі економіки перевезень здійснено методами системного та порівняльно-історичного аналізу, враховано економіко-географічне та геополітичне становище України. При обґрунтуванні науково-прикладного підходу використано методи верифікації та фальсифікації, економіко-математичного аналізу та моделювання.

Результати. Проаналізовано теоретичні та практичні проблеми розвитку перевезень вантажів різними видами транспорту. Проведено моделювання залежності обсягів реалізованої продукції (товарів, послуг) від обсягу вантажів, що перевозяться, в розрізі різних видів транспорту. Проаналізовано вплив обсягів перевезень на обсяги виробництва і продажу продукції найбільш значущих для національної економіки видів діяльності, які найбільше потребують транспортного обслуговування. Обґрунтовано найбільш доцільні види транспорту для здійснення інтермодальних і мультимодальних вантажоперевезень: залізничний, морський та внутрішній водний.

Висновки. Запропоновано науково-прикладний підхід до виявлення взаємозалежності виробництва та здійснення інтермодальних та мультимодальних перевезень продукції, який можна використовувати з метою підвищення конкурентних переваг транзитного потенціалу України.

Ключові слова: змішані перевезення вантажів, інтермодальні та мультимодальні перевезення, регулювання, кореляційно-регресійний аналіз, залізничний транспорт, морський транспорт, внутрішній водний транспорт.