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

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

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

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

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

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

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

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

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

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

Introduction. The strategic task of managing economic systems in the regions of Ukraine is to improve the quality and accessibility of transport and logistics services, taking into account internal and interregional ties. This can be achieved by modernizing the transport infrastructure and creating transport and logistics clusters as the "core" of the regional logistics system in the context of intensive development of the single European transport space. This is in line with the EU-Ukraine Association Agreement,

which aims to develop a multimodal logistics network linked to the Trans-European Transport Network (TEN-T) and to improve regional policy to better identify and evaluate the effectiveness of infrastructure projects for different types of transport.

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

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

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

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

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

Approaches to organizational modeling of logistics processes are analyzed and an improved method of distribution of organizational support for the functioning of logistics systems of enterprises is proposed, which includes conceptual, content, technological and reflective-evaluation components (T. Kolodizeva, A. Panasyants [48]).

Necessity and expediency of modeling business processes of industrial enterprise are substantiated, recommendations on introduction of logistic management in its activity are given, the theoretical and applied model of target function of logistics of

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industrial enterprise is resulted (R. Larina, O. Lukyanova [49]).

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

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

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

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

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

two-resource

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

multi-resource

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

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

where

$\hat{y}_t$ – production volumes;

K – volumes of capital investments;

L – average annual number of employees;

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

t – time factor;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\overline{T}_y = \overline{T}_{KL} \cdot \overline{T}_{масшт.}; \ \overline{T}_{масшт.} = \frac{\overline{T'}_y}{\overline{T}_{KL}} \quad (6)$$

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

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

Source: compiled and calculated by the authors

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

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

where

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

V_t – periodic component;

S_t – seasonal component;

ε_t – random component.

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

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

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

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

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

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

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

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

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

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

t – serial number of the year; $t = \overline{1, n}$;
n – length of observation period;
F_p, F_α – respectively, the estimated and tabular value of the F -criterion;
α – the level of reliability of the model.

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

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

Indicator, symbols	Optimal model of approximation ($\varepsilon_{відн.}$)	Fact 2020	Forecast values of the indicator by years		
			2021	2022	2023
Railway transport – Odesa railway					
Shipment of goods (y_1), *million tons*	Parabolic trend: $\hat{y}_1 = 25,55 + 0,572t - 0,011t^2$; $\varepsilon_{відн.} = 6,6\%$; $F_p = 28$	31.9	32.2	32.3	32.4
Freight turnover (y_2), *billion tkm*	$\hat{y}_2 = 49,68 + 2,26t - 0,106t^2$; $\varepsilon_{відн.} = 4,3\%$; $F_p = 5,07$	58.7	57.4	56.0	54.3
Road transport					
Volumes of cargo transportation in the area (y_3), *million tons*	$\hat{y}_3 = 73,37 - 3,025t + 0,141t^2$; $\varepsilon_{відн.} = 4,7\%$; $F_p = 6,0$	61.2	62.8	64.7	66.9
including: Odesa region (y_4)	Auroregression model of Box-Jenkins; $\varepsilon_{відн.} = 7,4\%$	29.8	30.1	30.5	30.8
Mykolaiv (y_5)	$\hat{y}_5 = 34,86 - 2,903t + 0,141t^2$; $\varepsilon_{відн.} = 4,1\%$; $F_p = 4,7$	24.5	26.3	28.3	30.7
Kherson (y_6)	Autoregressive model (AM) OLYMPUS; $\varepsilon_{відн.} = 7,1\%$; $F_p = 3,1$	13.5	13.0	12.8	12.9
Cargo turnover of the Black Sea region (y_7), *million tkm*	Logarithmic trend: $\hat{y}_7 = 2779,04 + 1274,42 \ln t$; $\varepsilon_{відн.} = 6,9\%$; $F_p = 60,1$	6312.5	6389.7	6462.6	6531.5
including: Odesa region (y_8)	$\hat{y}_8 = 1123,22 + 762,5 \ln t$; $\varepsilon_{відн.} = 9,3\%$; $F_p = 49,5$	3237.3	3283.5	3327.1	3368.1
Mykolaiv (y_9)	Integrated auroregression model; $\varepsilon_{відн.} = 8,9\%$; $F_p = 18,2$	1483.8	1522.4	1506.2	1514.0
Kherson (y_{10})	Integrated auroregression model; $\varepsilon_{відн.} = 5,9\%$; $F_p = 16$	1361.5	1312.0	1363.4	1363.9

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

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correspond to the laws of change of the parabolic trend, which is given to the model:

For example, the indicators of change in the volume of shipments by Odessa Railway

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

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

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

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

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

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

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

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

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

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

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

The dynamics of changes in the indicators that characterize the volume of processing of imported goods by stevedoring companies, shows that their regularity is significantly related to the events of 2014-2020, when

there was a significant decline in all seaports in the area. Some of them have a fairly high level of variation. For these reasons, most models do not meet the criteria of statistical accuracy and reliability - these are models for ports such as Izmail, Black Sea, Rhine and Kherson.

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

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

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

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

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

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

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

to form optimal multimodal logistics chains and to substantiate the regional cluster

model of organization of logistics activities in the Black Sea economic region;

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

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

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

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

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

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

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

The Port Landlord model is based on the following principles: the port administration, which has ownership or otherwise controls the use of port areas, is responsible for the planning and integrated development of

ports; private operators carry out stevedoring activities under a concession or lease agreement for assets and land with the port administration.

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

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

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