МЕНЕДЖМЕНТ

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MODELLING THE INTEGRAL PERFORMANCE OF TRANSPORT AND LOGISTICS CLUSTERS

Urgency of the research. *The success of the country's economic development is determined by the level of infrastructure development, in particular such its types as transport and logistics, which determine the speed of business processes and their ultimate efficiency. Nowadays Ukraine shows low ratings of the development of the transport and logistics market, which may negatively affect the country's participation in the world foreign trade turnover.*

Target setting. *One of the directions of improving the situation is the formation of transport and logistics clusters (TLC) as the most efficient form of the innovation-oriented integration of participants of the transport and logistics services market and the coordination of their economic interests throughout the chain of added value.*

Actual scientific researches and issues analysis. *The analysis of research on cluster problems has shown that carefully elaborated questions are the ones about identifying clusters, defining their types, as well as principles of cooperation and mechanisms of the state support.*

Uninvestigated parts of general matters defining. *The methodological approaches to determining the TLC performance require further development.*

The research objective. *The integral indicators of the transport and logistics cluster performance are modelled in the article in order to identify and provide practical support to those directions of the TLC development that have the greatest socio-economic potential.*

The statement of basic materials. *Four groups of indicators of the TLC performance are distinguished: economic, social, innovative and environmental. The most important indicators of the TLC performance for each of the groups were selected; and based on their expected dynamics, the integral indicators for each group indicator of the TLC performance were determined.*

Conclusions: *The modelled integral indicators of performance can be used to determine the impact on the overall TLC performance, as well as to analyse the dynamics of changes in the economic, environmental, social and innovative spheres in the process of functioning of the TLC.*

Keywords: *transport and logistics cluster; integral cluster performance; logistics; transport; modelling of cluster performance.*

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МОДЕЛЮВАННЯ ІНТЕГРАЛЬНОЇ ЕФЕКТИВНОСТІ ФУНКЦІОНУВАННЯ ТРАНСПОРТНО-ЛОГІСТИЧНИХ КЛАСТЕРІВ

Актуальність теми дослідження. *Успішність економічного розвитку країни визначається рівнем розвитку інфраструктури, зокрема таких її видів, як транспорт та логістика, котрі зумовлюють швидкість протікання бізнес-процесів та їх кінцеву ефективність. Україна сьогодні демонструє низькі рейтинги розвитку транспортно-логістичного ринку, що може негативно позначитися на участі країни в світовому зовнішньоторговельному обороті.*

Постановка проблеми. *Одним з напрямків поліпшення ситуації є формування транспортно-логістичних кластерів (ТЛК) як найбільш ефективної форми інноваційно орієнтованої інтеграції учасників ринку транспортно-логістичних послуг та узгодження їх економічних інтересів у всьому ланцюгу створення доданої вартості.*

Аналіз останніх досліджень та публікацій. *Аналіз досліджень з кластерної проблематики показав, що ретельно опрацьованими є питання щодо ідентифікації кластерів, визначення їх видів, а також принципів співпраці та механізмів державної підтримки.*

Виділення недосліджених частин загальної проблеми. *Потребують додаткової розробки методологічні підходи до визначення ефективності функціонування ТЛК.*

Постановка завдання. *У статті було модельовано інтегральні показники ефективності транспортно-логістичного кластеру з метою виділення та практичної підтримки тих напрямів розвитку ТЛК, які мають найбільший соціально-економічний потенціал.*

Виклад основного матеріалу. *Виділено чотири групи показників ефективності ТЛК: економічні, соціальні, інноваційні та екологічні. Відібрано найбільш вагомі показники ефективності функціонування ТЛК по кожній з груп та на основі їх очікуваної динаміки визначено інтегральні показники для кожного групового показника ефективності функціонування ТЛК.*

Висновки. *Змодельовані інтегральні показники ефективності можуть використовуватися для визначення впливу на загальну ефективність функціонування ТЛК, а також аналізу динаміки змін в економічній, екологічній, соціальній та інноваційній сферах в процесі функціонування ТЛК.*

Ключові слова: *транспортно-логістичний кластер; інтегральна ефективність кластера; логістика; транспорт; моделювання ефективності кластера.*

Urgency of the research. As the world experience shows, one of the most significant factors of economic growth is the formation of a transport and logistics system that covers various spheres of

activity in the country, because in today's business the most successful is considered not the manufacturer who offers the best product, but the one who provides the fastest supply chain. According to the international Logistics Performance Index (LPI) compiled by the World Bank, in 2016 Ukraine ranked 80th out of 160 countries. While the nearest geographical neighbours – Lithuania, Poland, Estonia, Latvia, Romania – were located respectively on the 29th, 33rd, 38th, 43rd and 60th positions [1].

Target setting. In the conditions of today's global economy, such low logistics ratings can have a very negative impact on Ukraine's participation in the world foreign trade turnover, its place and role in the formation of foreign economic relations, the development of the system of international transport corridors and the implementation of the transit potential of the country. These problems require an immediate solution at all levels from business to state. Based on the above, for domestic transport and logistics companies it is necessary to find effective ways to provide their competitiveness in the fight against international competitors. One of these directions is the formation of transport and logistics clusters (TLC) as the most efficient innovation-oriented form of integration of participants on the transport and logistics services market, which provides the maximum synergy effect on the basis of innovations and coordination of economic interests of all participants on the chain of added value.

Actual scientific researches and issues analysis. The cluster approach is widely used in the economies of Germany, the United States, Japan, Finland, China and several other countries. So, in the European Union, a full-fledged network of transport and logistics clusters has been formed, consisting of more than eighty TLCs, and the share of transport and logistics services provided by specialized organizations in the total turnover has reached 40%.

The works of foreign and domestic scientists are devoted to the solution of the problem of providing the economic development of companies in the transport and logistics market on the basis of cluster formation. Among the foreign researchers who thoroughly studied this problem, one should highlight S. Avdonyna [2], T. Danko [3], E. Kutsenko [3], M. Kastels [4], M. Porter [5], S. Rekord [6], and among the domestic ones – M. Voinarenko [7], S. Hrytsenko [8], M. Kyzym [9], V. Haustova [9], S. Sokolenko [10], and others. The analysis of scientific research of these authors gives grounds to state that the essence, types, functions, algorithms of cluster construction, sources of the formation of synergetic effects and certain mechanisms of interaction are sufficiently studied.

Uninvestigated parts of general matters defining. However, a number of aspects of forming and functioning of clusters, especially those related to the specifics of different types of economic activity, remain problematic. In particular, the methodological problems of forming and functioning of clusters in the transport and logistics sphere require a detailed study. It can also be stated that there is insufficient research on specific aspects and peculiarities of the cluster approach application to the activities of companies providing transport and logistics services; the identification of synergy sources and their cluster efficiency; the development of algorithms that provide the success of cluster initiatives.

The research objective. In connection with the above, the objective of the present research was to model the indicators of the transport and logistics cluster performance in order to identify and provide practical support to those directions of the TLC development that have the greatest potential for efficiency.

The statement of basic materials. From the point of view of the methodology and analysis of the efficiency of forming and functioning of TLC the use of economic and mathematical modelling is of considerable interest. A transport and logistics cluster as an object of modelling is a system whose complexity is determined by the number of its constituent elements (enterprises, organizations, subjects of socio-economic, scientific and technical purpose, etc.), the interconnections between them and the external environment. The associative integration of elements in the cluster implies the existence of common goals and interests. Meanwhile the elements of the cluster have their own goals and make active efforts to achieve them. The composition of cluster elements, the methods of their associative integration and the relations between them determine the structure of the cluster as an economic system, as well as its performance. It's very important in the process of the TLC formation to substantiate the optimal composition of the cluster participants, and above all the participation of certain transport and logistics enterprises as the main component of the cluster core.

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Based on the conducted research of analytical methods, with the help of which it is possible to model the efficiency of clustering of transport and logistics enterprises, it is expedient to use the simulation modelling to achieve the above objective. The stages of modelling the transport and logistics cluster performance are shown in Fig. 1.

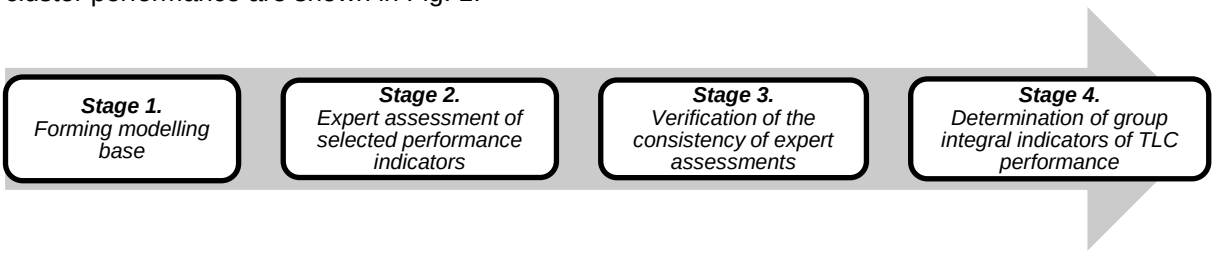

Fig. 1.The stages of modelling the transport and logistics cluster performance

To determine and select indicators of the efficiency of forming and functioning of a transport and logistics cluster, a survey was conducted among experts on the development of the transport and logistics market on the basis of a specially developed questionnaire. Analysing and grouping of the obtained data gave grounds for distinguishing four groups of indicators of the transport and logistics cluster performance: economic, social, innovative and environmental. In each group, five indicators were identified that were most often indicated by respondents, meanwhile the indicators that were close in content were united and generalized. The results of the research are presented in Tab. 1.

Table 1

Indicators of the transport and logistics cluster performance

Group indicators	Individual indicators
1. Indicators of the economic performance	X_{11} – increase in revenues from the provision of services; X_{12} – increase in workforce productivity; X_{13} – increase in capital investments; X_{14} – reduction of expenses from the provision of services; X_{15} – increase in profitability (ratio of total revenues to total expenses).
2. Indicators of the environmental performance	X_{21} – reduction of emissions to the environment due to the use of environmentally friendly modes of transport; X_{22} – reducing the impact of transport on the environmental through the introduction of innovative technologies; X_{23} – increasing compliance of vehicles with the requirements of international environmental standards (environmental safety of transport); X_{24} – reduction of payments for taxes and fees (environmental tax); X_{25} – reduction of fines for violation of environmental legislation.
3. Indicators of the innovative performance	X_{31} – return on assets; X_{32} –formation of new channels of technology transfer; X_{33} – increase in the number of developed and / or implemented information and management innovations; X_{34} – increase in the number of developed and / or implemented logistics innovations; X_{35} – increase in the number of developed and / or implemented transport innovations.
4. Indicators of the social performance	X_{41} – creating additional jobs; X_{42} – improvement of working conditions; X_{43} – increase in the number and quality of social communications; X_{44} – growth of the wage level of employees; X_{45} – advanced training of employees, growth of social status and opportunities for self-realization.

Source: created by the authors

The expert assessment of the selected indicators of the transport and logistics cluster performance was carried out in two stages. On the basis of the results of the first questionnaire of experts, a re-questionnaire was conducted in order to assess the importance of indicators of the transport and logistics cluster performance, as well as to forecast their dynamics for three years. The questionnaires in-

cluded 20 indicators of the transport and logistics cluster performance indicated by the overwhelming majority of respondents in the previous survey. The task of the experts was to assess each of the indicators – from 0 to 9 points in order of increasing the importance of the indicator and to predict its expected growth (decrease) during the first three years of functioning of the transport and logistics cluster.

The results of checking the consistency of the expert assessment of the importance of indicators by the rank correlation method using Student's t-test have shown that the empirical values of coefficients of the rank correlation for all indicators and all groups of experts are statistically significant and have a high probability level. The above gave grounds by the results of the expert assessment of weight coefficients and the expected dynamics of the TLC performance to determine the average values of such evaluation indicators as:

p_{ij} – weight coefficients of each individual indicator;

$d_{ij}^{(t)}$, $t = 1,2,3$ – forecasted values of coefficients of growth of the indicator x_{ij} for three years. The dynamics of the researched indicators of the TLC performance is given in Tab. 2.

Table 2

Expected dynamics of the researched indicators of the TLC performance

Group indicator	Individual indicator	Years of functioning		
		t =1	t =2	t =3
1. Economic performance	X_{11} X_{12} X_{13} X_{14} X_{15}	$1,02X_{11}$ $1,02X_{12}$ X_{13} $1,0101X_{14}$ $1,02X_{15}$	$1,1016X_{11}$ $1,122X_{12}$ $1,1X_{13}$ $1,04131X_{14}$ $1,0812X_{15}$	$1,2118X_{11}$ $1,2903X_{12}$ $1,32X_{13}$ $1,0961X_{14}$ $1,1677X_{15}$
2. Environmental performance	X_{21} X_{22} X_{23} X_{24} X_{25}	$1,0204X_{21}$ X_{22} $1,02X_{23}$ X_{24} X_{25}	$1,0741X_{21}$ $1,0204X_{22}$ $1,0710X_{23}$ $1,0101X_{24}$ $1,0204X_{25}$	$1,1935X_{21}$ $1,0741X_{22}$ $1,1460X_{23}$ $1,0636X_{24}$ $1,0629X_{25}$
2. Innovative performance	X_{31} X_{32} X_{33} X_{34} X_{35}	X_{31} $1,1X_{32}$ $1,1X_{33}$ $1,01X_{34}$ X_{35}	$1,04X_{31}$ $1,232X_{32}$ $1,265X_{33}$ $1,0605X_{34}$ $1,02X_{35}$	$1,1024X_{31}$ $1,4168X_{32}$ $1,518X_{33}$ $1,1666X_{34}$ $1,0608X_{35}$
4. Social performance	X_{41} X_{42} X_{43} X_{44} X_{45}	X_{41} $1,01X_{42}$ $1,01X_{43}$ X_{44} $1,04X_{45}$	$1,03X_{41}$ $1,0504X_{42}$ $1,0403X_{43}$ $1,02X_{44}$ $1,1232X_{45}$	$1,0918X_{41}$ $1,1134X_{42}$ $1,0923X_{43}$ $1,0710X_{44}$ $1,2355X_{45}$

Source: created by the authors

Note that p_{ij} must satisfy the condition: 1) $0 \le p_{ij} \le 1$; 2) $\sum_{j=1}^{n}\sum_{i=1}^{4} x_{ij} = 1$, where i is the number of the group indicator, j is the number of the individual indicator. To fulfil these conditions, the method of natural normalization was applied to the matrix of averaged expert assessments:

$$p_{ij}^{'} \to p_{ij} = \frac{p_{ij}^{'} - \min i, j\{p_{ij}^{'}\}}{\max i, j\{p_{ij}^{'}\} - \min i, j\{p_{ij}^{'}\}}, \quad (1)$$

where $p_{ij}^{'}$ is the expert assessment, p_{ij} is the normalized assessment.

Using the described approach, the following normalized matrices were obtained:

$$P_1 = \left|\left|p_{1j}\right|\right| = \begin{pmatrix} 0{,}67 \\ 0{,}56 \\ 0{,}67 \\ 0{,}44 \\ 0{,}67 \end{pmatrix} \rightarrow \begin{pmatrix} 0{,}0652 \\ 0{,}0543 \\ 0{,}0652 \\ 0{,}0435 \\ 0{,}0652 \end{pmatrix}, \quad (2)$$

$$P_2 = \left|\left|p_{2j}\right|\right| = \begin{pmatrix} 0{,}56 \\ 0{,}56 \\ 0{,}33 \\ 0{,}22 \\ 0{,}22 \end{pmatrix} \rightarrow \begin{pmatrix} 0{,}0610 \\ 0{,}0610 \\ 0{,}0396 \\ 0{,}0244 \\ 0{,}0244 \end{pmatrix}, \quad (3)$$

$$P_3 = \left|\left|p_{3j}\right|\right| = \begin{pmatrix} 0{,}67 \\ 0{,}56 \\ 0{,}44 \\ 0{,}22 \\ 0{,}56 \end{pmatrix} \rightarrow \begin{pmatrix} 0{,}0732 \\ 0{,}0610 \\ 0{,}0488 \\ 0{,}0244 \\ 0{,}0610 \end{pmatrix}, \quad (4)$$

$$P_4 = \left|\left|p_{4j}\right|\right| = \begin{pmatrix} 0{,}67 \\ 0{,}22 \\ 0{,}67 \\ 0{,}67 \\ 0{,}67 \end{pmatrix} \rightarrow \begin{pmatrix} 0{,}0732 \\ 0{,}0244 \\ 0{,}0732 \\ 0{,}0732 \\ 0{,}0732 \end{pmatrix}. \quad (5)$$

On the basis of the above matrices, the integral indicators for each group indicator of the TLC performance were determined:

$$I_1 = \left|\left|p_{1j}\right|\right| \cdot x_{1j} = \\ = 0{,}0652x_{11} + 0{,}0543x_{12} + 0{,}0652x_{13} + 0{,}0435x_{14} + 0{,}0652x_{15}, \quad (6)$$

$$I_2 = \left|\left|p_{2j}\right|\right| \cdot x_{2j} = \\ = 0{,}0610x_{21} + 0{,}0610x_{22} + 0{,}0396x_{23} + 0{,}0244x_{24} + 0{,}0244x_{25}, \quad (7)$$

$$I_3 = \left|\left|p_{3j}\right|\right| \cdot x_{3j} = \\ = 0{,}0732x_{31} + 0{,}0610x_{32} + 0{,}0488x_{33} + 0{,}0244x_{34} + 0{,}0610x_{35}, \quad (8)$$

$$I_4 = \left|\left|p_{4j}\right|\right| \cdot x_{4j} = \\ = 0{,}0732x_{41} + 0{,}0244x_{42} + 0{,}0732x_{43} + 0{,}0732x_{44} + 0{,}0732x_{45}. \quad (9)$$

The resulting formulas for the calculation of integral indicators have the following properties: when substituting normalized relative values of x_{ij}, which can vary from 0 to 1,into the corresponding formula, the normalized value of the integral indicator is obtained as well, whereby in the case when all x_{ij}acquire the maximum values, the corresponding value of the integral indicator is equal to 1. This allows you to use the resulting formulas for:

– comparing the relative performance of the transport and logistics cluster for different groups of indicators;

– calculating the effect of development (financing, support, etc.) of each of the selected individual indicators and assessing their impact on the overall TLC performance;

– dynamic analysis of changes in the economic, environmental, social and innovative spheres in the process of the TLC functioning for certain periods of time.

Conclusions. The modelled analytical approach to the computation of integral indicators of economic, social, innovative and environmental performance, generated as a result of the interaction of participants of the transport and logistics cluster, provides a practical opportunity to quantitatively assess the areas of cooperation and to choose its most efficient type. The presented approach is rather flexible, as it provides for the possibility of changing the evaluation indicators and studying various op-

tions for combining the areas of cluster cooperation. It should also be noted that obtaining economic, social, innovative and environmental effects as a result of cluster cooperation is situational and depends on the stage of cluster development, the level of economic development of its participants, technological and material resources that are accessible to participants, their readiness to coordinate common directions of economic activity.

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