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SIMULATION MODELLING OF STRATEGIC DEVELOPMENT OF TRANSPORT AND LOGISTICS CLUSTERS IN UKRAINE

Oksana Karpenko[1], Olena Palyvoda[2]
State University of Infrastructure and Technology, Ukraine

Olena Bondarenko[3]
National University of Trade and Economics, Ukraine

Abstract. *The aim*. The article is devoted to the development of methodological approaches to the strategic management of the development of transport and logistics clusters, which take into account opportunities and barriers, especially the domestic economic environment, as well as the specifics of certain types of economic activity. *Methods*. The economic and mathematical model is substantiated using the Savage criterion, which gives an opportunity to choose the optimal strategy of transport and logistics cluster development in the domestic conditions of management taking into account the different expectations of business entities. Methods similar to the Wald, Bayesian and Savage criteria were used for choosing optimal strategies in decision making theory and optimization problems of the following types were solved: when the distribution of states of the environment is unknown and assumed to be the most unfavourable; when it is known empirical expected distribution of environmental conditions and that is the average expected performance level for each indicator's group; when it is known expected division of the priorities of the decision-making entity that is the average expected level of financial (organizational, etc.) support for a certain group of indicators. *Results*. Four types of "clean" cluster development strategies are identified and described, which can be used in various combinations by transport and logistics companies. The economic and mathematical model of the transport and logistics cluster performance is presented, which allows implementing a large number of combinations of types of cluster development strategy by taking economic, environmental, social and innovative measures, affecting different groups of performance indicators. The influence of all possible variants of the binary and ternary combination of different types of transport and logistics cluster development strategies on the cluster performance is considered. It is established that the greatest influence on the transport and logistics cluster performance is exerted by the combination of economic and innovative types of strategy. *Practical significance*. Given the interest of entrepreneurs in cluster forms of organization and the strengthening of cooperation with EU countries, present development promotes scientific approaches to modelling cluster development strategies in the economy of Ukraine. *Relevance/originality*. The developed simulation model increases the likelihood of implementing the most optimal combination of "clean" development strategies, contributes to a more accurate prediction of cluster development and as a methodological approach can be applied to various types of economic activity.

Key words: transport and logistics cluster, simulation modelling, strategic development of transport and logistics cluster, cluster performance, logistics, transport.

JEL Classification: D85, O18

1. Introduction

The need to ensure competitive advantages of the national economy in the global economy motivates to search for organizational and managerial methods and forms that could, under the conditions of permanent economic and technological changes, contribute to the successful adaptation and development of economic actors. The formation and operation of regional clusters is a kind of answer to this task, because, as the world

Corresponding author:
[1] Department of Management and Economics of Water Transport, State University of Infrastructure and Technology.
E-mail: karpo_2004@ukr.net
[2] Department of Management and Economics of Water Transport, State University of Infrastructure and Technology.
E-mail: Palyvoda_olena@ukr.net
[3] Department of Finance, National University of Trade and Economics.
E-mail: e95bond@gmail.com

practice shows, they represent peculiar growth points that accelerate and strengthen the innovative orientation of the economy, lay the foundations of competitiveness and investment attractiveness. Regional clusters also act as an instrument that forms a particularly favourable environment for the development of small and medium-sized business and promotes the generation of synergetic and multiplicative effects that have a positive influence on the development of the economy, raising the level and quality of life of the population, both in individual regions and in the country as a whole.

In Ukraine, there is a strong interest in the idea of economic development based on clusters, both among government officials and in the scientific and business environment. This is evidenced by the formal declaration of about two dozen clusters in various types of economic activity in Ukraine. But it should be noted that the overwhelming majority of initiated clusters has merely declarative nature and does not provide for the real economic cooperation. However, given the interest of entrepreneurs and scientists in a cluster form of entrepreneurship and taking into account the increased cooperation with EU countries, there is an urgent need to develop scientific approaches to analysing and modelling strategies for the cluster formation and development in the economy of Ukraine, forecasting the consequences of their operation in the domestic economic space, assessing the integral cluster performance.

The research of the problems of cluster network operation is quite active and careful taking place in western and domestic economic science during the last decades. At present, the questions of the nature, types, goals, tasks, stages of formation, and mechanisms of interaction between enterprises in clusters, as well as directions and forms of the state support are comprehensively considered in the works of such researchers, as M. Porter, M. Castells, M. Enright, O. Solvell, G. Lindqvist, Ch. Ketels, M. Voinarenko, V. Tarasenko and others.

Despite the existence of significant scientific research results in the field of cluster development, the research and formulation of the peculiarities of cluster operation in certain types of economic activity, in particular transport and logistics, remains relevant. There is also a practical interest in the formulation and selection of the optimal cluster development strategies that take into account the opportunities and barriers, first of all, of the domestic economic environment.

Taking the above into consideration, the objective of the presented research is to develop an economic and mathematical model using the Wald, Bayesian, and Savage criteria, and on its basis to analyse the influence of the binary and ternary combination of different types of transport and logistics cluster development strategies on the expected cluster performance, with the subsequent selection of the optimal strategy for cluster development under the domestic conditions of management.

2. Types of probable "clear" strategies for the development of transport and logistics clusters

The study of the practice of European clusters' operation shows that the main types of performance that can be generated by the cluster cooperation are: economic, social, environmental, and innovative. In previous works, we implemented the modelling of cluster efficiency in abovementioned directions and calculated their integral indicators on the basis of groups of indicators (Fig. 1) (Karpenko, Palyvoda, Bondar, 2018).

However, in order to ensure the efficiency of cluster performance, the necessary condition is the forecasting and selection of cluster development strategies that are optimal in the domestic business environment. To accomplish this task, we identified and studied four types of possible "pure" strategies for the development of transport and logistics clusters (TLC):

1) the strategy for the economic development of TLC, which is associated with changes in production, organizational and managerial activities of transport and logistics enterprises (TLE), aimed at increasing profit and profitability of transport and logistics enterprises, increasing competitiveness, making the best use of available resources, improving the quality of transport and logistics services, increasing the share and developing new market segments, attracting investments, improving the management system, the widest implementation of information and communication technologies, etc.

2) the strategy for the environmental development of TLC, which is aimed at the implementation of environmental and economic interests by reducing harmful emissions into the environment through the use of cleaner modes of transport, reducing the influence of transport on the environment through the introduction of innovative technologies, achieving compliance of vehicles with the requirements of international environmental standards, raising the level of environmental consciousness of the population;

3) the strategy for the social development of TLC, which is aimed at achieving general welfare and collective security on the basis of mutual responsibility, transparency, ethical behaviour, observance of legal norms, observance of international norms, protection of human rights, increasing the number of jobs, improving working conditions, ensuring an uninterrupted improvement of the educational and professional level of workers, adequate wages, availability of social benefits;

4) the strategy for the innovative development of TLC, which provides for the efficient development and

Indicators of the economic performance
– increase in revenues from the provision of services; – increase in workforce productivity; – increase in capital investments; – reduction of expenses from the provision of services; – increase in profitability (ratio of total revenues to total expenses).
Indicators of the environmental performance
– reduction of emissions to the environment due to the use of environmentally friendly modes of transport; – reducing the impact of transport on the environment through the introduction of innovative technologies; – increasing compliance of vehicles with the requirements of international environmental standards (environmental safety of transport); – reduction of payments for taxes and fees (environmental tax); – reduction of fines for the violation of environmental legislation.
Indicators of the innovative performance
– return on assets; – formation of new channels of technology transfer; – increase in the number of developed and/or implemented information and management innovations; – increase in the number of developed and/or implemented logistics innovations; – increase in the number of developed and/or implemented transport innovations.
Indicators of the social performance
– creating additional jobs; – improvement of working conditions; – increase in the number and quality of social communications; –growth of the wage level of employees; – advanced training of employees, growth of social status and opportunities for self-realization.

Fig. 1. Indicators of cluster performance

implementation of managerial, logistics and transport innovations based on strategic marketing, research and development works, modern information and communication technologies, available scientific and technical and intellectual potential of the enterprise, use of the channels of technology and knowledge transfer, development of intellectual needs of the staff, stimulation of creative approach to the tasks performed, constant knowledge development by the staff in the process of professional activity.

2. Modelling the efficiency of the cluster functioning at different expectations

In order to determine the dynamics of the groups of indicators of the TLC performance (Fig. 1), recurrence relations were given:

$$f^t(x_{ij})=g(d_{ij}^1)x_{ij}+g(d_{ij}^2)g(d_{ij}^1)x_{ij}+g(d_{ij}^3)g(d_{ij}^2)g(d_{ij}^1)x_{ij}, \quad (1)$$

where $g(d_{ij}^t)$ is the function of the expected value of the growth factor of the indicator x_{ij} for the year t, which is a linear function in the case when the factor is an indicator with a positive ingredient and inverse for a factor with a negative ingredient. The results of the previous modelling of the dynamics of integral indicators of the transport and logistics cluster performance are presented in Table 1.

Table 1

Integral indicators of the expected transport and logistics cluster performance by group indicators

Integral indicator of the TLC performance	Years of the TLC operation			
	t=0	t=1	t=2	t=3
Economic performance	0,2935	0,2976	0,3203	0,3591
Environmental performance	0,1848	0,1865	0,1929	0,2068
Innovative performance	0,2826	0,2920	0,3128	0,3470
Social performance	0,2391	0,2423	0,2253	0,2696

Source: developed by the authors

The implementation of the above formulas is shown for the case $g(x^+)=x^+$ and $g(x^-)=1/x^-$. Based on the data presented in Table 1, we have modelled the evaluation matrix of performance. In the model example, let us assume that all x_{ij} acquire single values. Consequently, this allows us to get the evaluation function with a positive ingredient of this type (formula 2):

$$F^{+}=\begin{pmatrix}0,0665 & 0,0718 & 0,0790\\ 0,0554 & 0,0610 & 0,0701\\ 0,0652 & 0,0717 & 0,0816\\ 0,0439 & 0,0453 & 0,0477\\ 0,0665 & 0,0705 & 0,0762\\ 0,0555 & 0,0584 & 0,0649\\ 0,0543 & 0,0555 & 0,0584\\ 0,0333 & 0,0349 & 0,0374\\ 0,0217 & 0,0220 & 0,0231\\ 0,0652 & 0,0672 & 0,0712\\ 0,0549 & 0,0571 & 0,0605\\ 0,0439 & 0,0452 & 0,0475\\ 0,0217 & 0,0222 & 0,0233\\ 0,0565 & 0,0610 & 0,0671\\ 0,0652 & 0,0678 & 0,0719\\ 0,0239 & 0,0268 & 0,0308\\ 0,0717 & 0,0825 & 0,0990\\ 0,0659 & 0,0692 & 0,0761\\ 0,0652 & 0,0665 & 0,0692\end{pmatrix} \quad (2)$$

After the "convolution" operation taking into account weighting factors, an evaluation matrix for the groups of indicators was obtained:

$$F=\left\|f_{ij}\right\|=\begin{pmatrix}0,297613 & 0,186544 & 0,242283\\ 0,320350 & 0,192898 & 0,252709\\ 0,359053 & 0,206828 & 0,269639\\ 0,297613 & 0,186544 & 0,242283\end{pmatrix}. \quad (3)$$

For the study of the obtained evaluation matrix, approaches similar to the Wald, Bayesian, and Savage criteria of selecting optimal strategies in the decision-making theory (Vitlinskyi, Velikoivanenko, 2004) were used, that is, the optimization problems of the following types were solved:

1. Optimization provided that the distribution of states of the environment is unknown and assumed antagonistic (the most unfavourable) for the subject of decision-making:

$$z=V\rightarrow\max, \quad (4)$$

$$\begin{cases}\sum_{j=1}^{4} f_{ij}w_i \geq V,\\ \sum_{i=1}^{20} w_i = 1,\\ 0 \leq w_{min} \leq w_i \leq w_{max},\end{cases} \quad (5)$$

Where w_i is the relative share of available resources for the TLC development, which is directed to the implementation of the i-th strategy, w_{min} and w_{max} are respectively the least and most expected values, which in practice should be determined by expert evaluation, f_{ij} are the elements of the matrix F, V is the integral indicator of the TLC performance.

On converting the model to an equivalent form:

$$g=\sum_{i=1}^{4} t_i = \frac{1}{V} \rightarrow \min, \quad (6)$$

$$\begin{cases}\sum_{j=1}^{4} f_{ij}t_i \geq 1,\\ t_i = \frac{w_i}{V},\\ 0 \leq t_{min} \leq t_i \leq t_{max},\end{cases} \quad (7)$$

The result was obtained: w_1=0,2847,w_2=0,2293, w_3=0,2563, w_4=0,2297, V=0,2834. Consequently, according to the Wald criterion, in order to ensure the transport and logistics cluster performance in the amount of 28.34%, it is expedient to allocate 28.47% of the available resources to the implementation of the strategy of economic development, 22.93% – environmental development, 25.63% – social development, 22.97% – innovative development of TLC.

2. Optimization, provided that the empirical expected distribution of states of the environment is known, in our case, it is the average expected level of performance for each group of indicators. Let us denote this distribution by $\lambda=(\lambda_1;\lambda_2;\lambda_3;\lambda_4)$, $0\leq \lambda_1 \leq 1$, $\sum_{i=1}^{4} \lambda_i=1$. In this case, the Bayesian criterion was applied and the following model is obtained:

$$z = V \rightarrow \max, \quad (8)$$

$$\begin{cases}\sum_{j=1}^{4} \lambda_i f_{ij} w_i \geq V,\\ \sum_{i=1}^{20} w_i = 1,\\ 0 \leq w_{min} \leq w_i \leq w_{max},\end{cases} \quad (9)$$

In practice, it is expedient to use a model of this type after a certain period of time after the start of cluster operation; in this case, it is possible to estimate the value of $\lambda=(\lambda_1;\lambda_2;\lambda_3;\lambda_4)$ empirically.

3. Optimization, provided that the expected division of priorities of the decision-maker is known, in our case, it is the average expected level of financial (organizational, etc.) support for a certain group of indicators. This distribution was denoted by: $\mu=(\mu_1;\mu_2;\mu_3;\mu_4)$, $0\leq\mu_i\leq 1$, $\sum_{i=1}^{4}\mu_i=1$ and the following model is obtained:

$$z=\sum_{i=1}^{4}\frac{\mu_i w_i}{V}\rightarrow\min, \quad V\rightarrow\max, \quad (10)$$

$$\begin{cases}\sum_{j=1}^{4} f_{ij}\mu_i w_i \geq V,\\ \sum_{i=1}^{20} \mu_i w_i = 1,\\ 0 \leq w_{min} \leq w_i \leq w_{max},\end{cases} \quad (11)$$

1. Economic and environmental development of TLC. In this case, the following values are assumed:

$\mu_3 = \mu_4 = 0$, $\mu_1 > 0$, $\mu_2 > 0$, $\mu_1 + \mu_2 = 1$. We also considered the values of weighting factors as variables. After the implementation of the model, we obtained the following result: $w_1 = 0,6802$, $w_2 = 0,3198$, $w_3 = 0$, $w_4 = 0$, $V = 0,2621$.

2. Economic and social development of TLC. In this case, the following values are assumed: $\mu_2 = \mu_4 = 0$, $\mu_1 > 0$, $\mu_3 > 0$, $\mu_1 + \mu_3 = 1$. After the implementation of the model, we obtained the following result: $w_1 = 0,6599$, $w_2 = 0$, $w_3 = 0,3401$, $w_4 = 0$, $V = 0,2788$.

3. Economic and innovative development of TLC. In this case, the following values are assumed: $\mu_2 = \mu_3 = 0$, $\mu_1 > 0$, $\mu_4 > 0$, $\mu_1 + \mu_4 = 1$. After the implementation of the model, we obtained the following result: $w_1 = 0,6394$, $w_2 = 0$, $w_3 = 0$, $w_4 = 0,3606$, $V = 0,2957$.

4. Social and environmental development of TLC. In this case, the following values are assumed: $\mu_1 = \mu_4 = 0$, $\mu_2 > 0$, $\mu_3 > 0$, $\mu_2 + \mu_3 = 1$. After the implementation of the model, we obtained the following result: $w_1 = 0$, $w_2 = 0,2768$, $w_3 = 0,7232$, $w_4 = 0$, $V = 0,2269$.

5. Social and innovative development of TLC. In this case, the following values are assumed: $\mu_1 = \mu_3 = 0$, $\mu_2 > 0$, $\mu_4 > 0$, $\mu_2 + \mu_4 = 1$. After the implementation of the model, we obtained the following result: $w_1 = 0$, $w_2 = 0,3156$, $w_3 = 0$, $w_4 = 0,6844$, $V = 0,2587$.

6. Innovative and environmental development of TLC. In this case, the following values are assumed: $\mu_1 = \mu_2 = 0$, $\mu_3 > 0$, $\mu_4 > 0$, $\mu_3 + \mu_4 = 1$. After the implementation of the model, we obtained the following result: $w_1 = 0$, $w_2 = 0$, $w_3 = 0,4358$, $w_4 = 0,5642$, $V = 0,2753$.

The results of the study of influence of the binary combination of strategy types on the transport and logistics cluster performance are presented in Table 2.

As a result of the comparison of influence of the binary combination of different types of TLC development strategies, it has been discovered that the combination of economic and innovative types of strategy has the greatest influence on the transport and logistics cluster performance, which allows ensuring the expected integral performance in the amount of 29.57% after three years of the TLC operation. The results of the study of the influence of the ternary combination of different types of TLC development strategies on the transport and logistics cluster performance are presented in Table 3.

The comparison of influence of the ternary combination of different types of TLC development strategies has shown that the combination of social,

Table 2

Results of the study of the influence of the binary combination of different types of cluster development strategies on the cluster performance

Variants of the binary combination of different types of TLC development strategies	Relative indicator of the TLC performance, V	Relative frequency, w_i			
		W_1, economic performance indicators	W_2, environmental performance indicators	W_3, social performance indicators	W_4, innovative performance indicators
Economic and innovative	0,2957	0,6394	0	0	0,3606
Economic and social	0,2788	0,6599	0	0,3401	0
Innovative and environmental	0,2753	0	0	0,4358	0,5642
Economic and environmental	0,2621	0,6802	0,3198	0	0
Social and innovative	0,2587	0	0,3156	0	0,6844
Social and environmental	0,2269	0	0,2768	0,7232	0

Note: developed by the authors

Table 3

Results of the study of the influence of the ternary combination of different types of TLC development strategies on the TLC performance

Types of TLC development strategy	Relative indicator of the TLC performance, V	Relative frequency, w_i			
		W_1, economic performance indicators	W_2, environmental performance indicators	W_3, social performance indicators	W_4, innovative performance indicators
Social and innovative and environmental	0,2732	0	0,3333	0,3333	0,3333
Economic and innovative and environmental	0,2605	0,3643	0,3178	0	0,3178
Economic and social and environmental	0,2475	0,3964	0,3010	0	0,3026
Economic and social and innovative	0,2455	0,4010	0	0,2993	0,2997

Note: developed by the authors

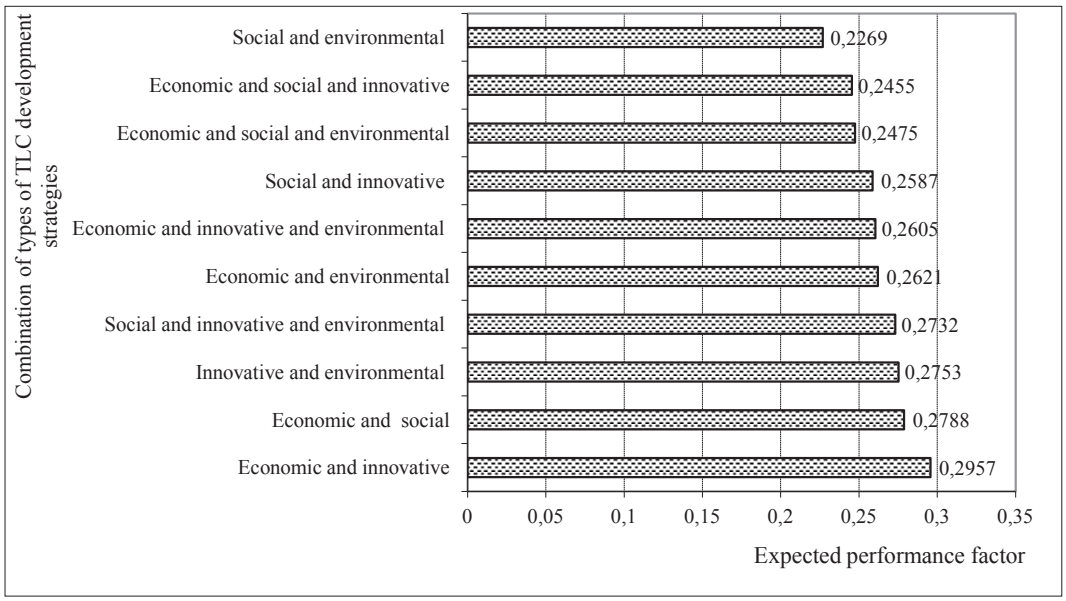

Fig. 2. Results of comparison of the influence of the binary and ternary combination of different types of TLC development strategies

Note: developed by the authors

innovative, and environmental types of strategy has the greatest influence on the transport and logistics cluster performance, which allows ensuring the expected integral performance in the amount of 27.32% after three years of the TLC operation.

On the basis of the developed economic and mathematical model, the influence of the binary and ternary combination of different types of TLC development strategies on the expected integral performance of transport and logistics cluster is determined (Fig. 2).

4. Conclusion

As a result of the comparison of influence of the binary and ternary combination of different types of TLC development strategies, it has been discovered that the combination of economic and innovative types of strategy has the greatest influence on the transport and logistics cluster performance, which allows ensuring the expected integral performance in the amount of 29.57% after the first three years of operation of the formed transport and logistics cluster.

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