TRANSPORT PROBLEMS 2025 Volume 20 Issue 2
PROBLEMY TRANSPORTU DOI: 10.20858/tp.2025.20.2.16

Keywords: transport; transport sector; economic efficiency; efficiency; transport policy; CO_2 emissions; sector factors; macroeconomic factors; cluster; level of development

Nataliia BONDAR[1]*, Jacek STROJNY[2]

EFFICIENCY OF TRANSPORT POLICIES IN EU COUNTRIES

Summary. Strengthening the national economy and ensuring competitiveness in international markets requires tools for objectively assessing the effectiveness of government policy. It is important to evaluate the economic effectiveness of transport policy in comparison with other countries. A conceptual approach is proposed for assessing the economic efficiency of state transport policy through the country's transport performance indicators. The added value created in the transport sector per employee is proposed as an indicator of economic efficiency. The results of the transport sector's activities are influenced by both macroeconomic factors and sector-specific factors that impact its functioning and development trends. Therefore, to determine the effectiveness of a country's transport policy, it is proposed to use clustering based on macroeconomic indicators and transport sector indicators. These indicators were selected based on their correlation with the value of added value created in the transport sector per employee. Four clusters of EU countries were formed. The clustering results obtained using Vard's dendrogram were confirmed by the k-means grouping method. The clustering results showed that the distribution of countries across clusters differs when examining the impact of macroeconomic factors and the level of development in the transport sector. There are situations when countries in a stronger cluster in terms of macroeconomic indicators move to a cluster with average transport sector performance. Information on a country's position among clusters and within a cluster, compared to other comparable countries in terms of transport sector performance indicators, will provide an objective assessment of the effectiveness of state transport policy. This confirms the thesis that transport policy implementation tools must be comprehensive and taken into account when developing programmes and strategies for the development of both the transport sector and other sectors or regions of the country. They must also take into account inter-sectoral links, the impact on the socio-economic well-being of the population and the security of the country. A generalized model for the formation of state transport policy is also presented, taking into account the results of an analysis of the achieved transport performance indicators and the identification of possible target indicators as well as the best practices of the cluster countries. The monographic method, abstraction, comparative analysis, statistical correlation analysis, cluster analysis, and graphical and analytical methods were used in the work. The information base was compiled through modern research by scientists in the field of the transport sector's effective functioning, state transport policy, and official data from the Statistical Office of the European Union.

1. INTRODUCTION

The economic development of any country is closely linked to the efficiency of its economic sectors. One of the most important infrastructure sectors of a modern country's economy is transport. It influences the balanced economic development of a country's territories, ensures connections between other sectors of material production, promotes population mobility, stimulates business activity, and facilitates domestic and

[1] Rzeszow University of Technology; al. Powstańców Warszawy 12, 35-959 Rzeszow, Poland; e-mail: n.bondar@prz.edu.pl; orcid.org/0000-0002-8254-2449
[2] Rzeszow University of Technology; al. Powstańców Warszawy 12, 35-959 Rzeszow, Poland; e-mail: jstrojny@prz.edu.pl; orcid.org/0000-0003-4632-8645
* Corresponding author. E-mail: n.bondar@prz.edu.pl

international trade. Additionally, the development of transportation and transportation infrastructure has a direct impact on a country's national security.

Governments implement national transport policies through state regulation. The need to assess the effectiveness of state regulation in transport is caused by several circumstances, in particular: 1) the sector is strategic, as it not only ensures national security but also creates the conditions for the balanced development of the country's regions and the standard of living of the population [5, 19]; 2) the level of development and efficiency of the transport sector have a direct impact on the business activity of other material production industries [16, 6, 24]; 3) investments in the development and maintenance of transport infrastructure are capital-intensive and are financed mainly from centralized financial resources (state and local budgets) [20]; 4) the monopolistic nature of certain types of transport (e.g., railways, motorways, seaports) removes incentives for the state to improve economic efficiency. This is due to the lack of need to gain competitive advantages over other market participants [8, 7, 14]; 5) losses incurred by society as a result of ill-considered transport policy cannot be compensated (e.g., lost resources, environmental pollution) [21, 18]; 6) uncontrolled or poorly regulated transport operations pose a threat to traffic safety, the environment, and the health and lives of the population [13]; and 7) by controlling transport tariffs, governments ensure that transport services are accessible to the poor [23].

The consequences of state regulation of the transport sector are reflected in the national economy's overall economic growth indicators, international economic cooperation activity, employment levels, and changes in the population's standard of living [5, 24, 13]. Thus, objective information on the level of efficiency of the transport sector is necessary for the development of state and regional economic development programs and for ensuring international competitiveness.

The objectives of this article are as follows: 1) to develop a conceptual approach to assessing the effectiveness of state transport policy; 2) to identify groups of key factors that determine the performance of the transport sector as a whole; 3) to identify groups (clusters) of countries that are similar in terms of the efficiency of the transport sector (efficiency of state transport policy) based on cluster analysis; and 4) to formulate a generalized model for the formation of state transport policy.

The results of the study allow for an objective assessment of the effectiveness of transport in comparison with other countries, identify the factors that determined specific indicators of its performance, and determine priority areas for the development of national and regional programs for the sector by the government.

2. CONCEPTUAL APPROACH TO ASSESSING THE EFFECTIVENESS OF STATE TRANSPORT POLICY

The government's transport policy has a significant impact on the country's economic development, the quality of life in society, environmental conditions, and national security. Various indicators are used to assess the effectiveness of transport policy in these areas.

A common approach to assessing the effectiveness of transport policy is to evaluate it in terms of social justice [9, 10]. Researchers consider horizontal justice (access to resources for all individuals or groups), vertical equality in terms of income and social class (giving advantages to economically and socially vulnerable groups to compensate for injustice), and vertical equality in terms of mobility needs and opportunities (transport takes into account the needs of all users, including those with special needs) [12].

Transport is the second largest source of greenhouse gas emissions in the European Union [3]. Greenhouse gas emissions from road transport pose a serious threat to air quality in cities and contribute to global warming [11]. In order to eliminate the negative impact of transport on the environment and the country's population, scientists have studied policies aimed at changing current unfavorable trends, in particular by restricting the use of private vehicles, reducing road freight transport, reducing air traffic related to freight and passenger transport, reducing energy consumption in transport, and reducing accidents [22, 17]. Transport policy has also been evaluated based on passenger and freight transport safety, reliability, efficiency, and environmental performance [19, 18]. In European countries, many of these individual transport policies were initially introduced at the local or national level and then promoted at the European and pan-European levels [15].

As we can see, the effectiveness of the government's transport policy can be described by indicators that relate to various aspects and are multidimensional. At the same time, the transport sector itself is heterogeneous. Different modes of transport differ in terms of transport technology, the specific operating conditions of rolling stock and its cost, the technical characteristics and capital intensity of the necessary infrastructure, the composition of operating costs by type, the cost of resources consumed, the approach to tariff setting, and the requirements for professional training of employees. Therefore, even passenger transport by different modes of transport will differ in terms of travel time, fare, safety, infrastructure accessibility, carrier costs, and insurance costs [4]. In addition, due to the country's geographical features, its transport system may not have all the necessary modes of transport. For example, this may be due to a lack of access to the sea, the predominantly mountainous terrain of the territory, or its island location. This raises the question of how to objectively assess the overall efficiency of a country's transport system.

This paper focuses on the economic efficiency of transport operations. The transport sector's contribution to the country's gross domestic product is significant. It is proposed to assess the efficiency of transport based on labor productivity, calculated as the added value in the sector per employee. This indicator is comparable in terms of both individual modes of transport and the transport sector as a whole in international comparisons.

The development and functioning of the transport sector are complex issues that require a systematic approach. A systematic approach involves considering a complex object as a relatively independent system with its own characteristics of functioning and development. We propose starting from the assumption that the effectiveness of state transport policy is reflected in transport performance indicators, which, in turn, reflect the level of transport development in the country. Thus, the implementation of state transport policy is reflected in the achieved indicators of accessibility, noise levels, and harmful emissions into the air, as well as traffic safety and delivery speed. The achievement of transport efficiency targets can be used to assess the level of development of transport infrastructure, the introduction of green transport, logistics, and the use of modern communication technologies in transport, among other factors. In other words, there is a dialectical relationship between the effectiveness of state transport regulation, the efficiency of transport operations, and the level of transport development in a country. The level of transport development achieved reflects the results of decisions made in the field of state regulation and their implementation in the sector. Therefore, based on our hypothesis, the economic efficiency of state transport regulation can be assessed by the level of development it has achieved (Fig. 1).

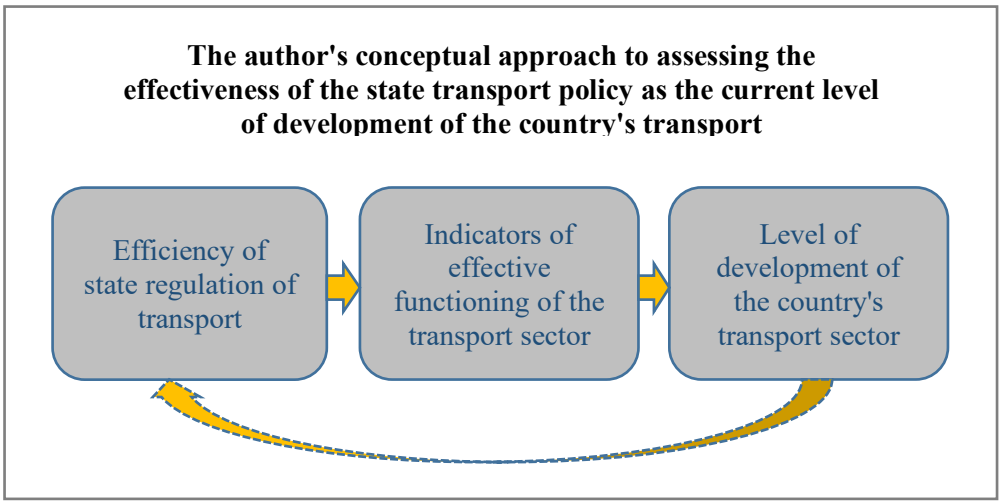

Fig. 1. The author's conceptual approach to assessing the effectiveness of the state transport policy at the current level of development of the country's transport. Source: author's own research

Within the national economy, it is impossible to compare the level of efficiency of its individual sectors. This is because the results of each sector are influenced by both systematic factors (e.g., current legislation, the economic, political, environmental, and demographic situation in the country, the availability of raw materials and energy resources, market conditions) and the characteristics of the industry itself (e.g., the type of resources consumed in the industry, belonging to natural monopolies, existing technologies and production methods, pricing, state regulations). In this case, the level of efficiency of a country's industry can be determined only by comparing its performance with that of the same industry in other countries. The higher the performance indicators of an industry in a country, the higher its level of development and the effectiveness of its management.

At the same time, the functioning of any industry is influenced by factors:

1) external to the country under study (e.g., global financial crises, wars, climate change, pandemics). Such factors affect several or all countries in the region. The government of an individual country cannot influence them;
2) internal to the country under study, which the government also cannot objectively influence: natural climatic conditions, geographical location of the country, raw materials, and natural resources;
3) internal to the country under study, which the government can influence. These include economic, social, foreign economic, demographic, environmental, innovation, investment, natural resource use, economic security, and individual industry development policies.

The first two groups of factors are objective economic conditions that create certain resource constraints over which the government has no influence. Therefore, we will now consider factors that the government can influence. They can be divided into those that are formed at the level of the country as a whole and characterize its economy (e.g., macro-level factors: GDP per capita, inflation index, the tax burden on taxpayers) and those that are formed at the level of a specific industry, in particular transport (e.g., meso-level factors: technological characteristics of the industry (e.g., capital intensity of infrastructure, energy intensity, the labor intensity of the industry, availability of raw materials), labor productivity in freight and passenger transport, availability of labor resources, wage levels).

Fig. 2 illustrates the proposed algorithm for assessing the level of efficiency in the transport sector, considering the impact of macro and meso factors. Information on the country's position among clusters and within clusters, compared to other comparable countries in terms of transport sector performance indicators, will provide an objective assessment of the effectiveness of state transport policy. Information on the performance indicators achieved in the transport sector will also serve as a basis for government decisions to improve the sector's efficiency. Knowledge of the strength and direction of macroeconomic and sectoral factors will enable the government to justify the directions and measures for implementing the transport sector development program, ensuring not only the improvement of its functioning but also the socio-economic development of the country as a whole.

3. RESEARCH METHODOLOGY

This research employed the monographic method, abstraction, comparative analysis, statistical correlation analysis, cluster analysis, and graphical and analytical methods. The information base was based on modern research by scientists in the field of efficient transport functioning, the formation of state transport policy, and official data from the Statistical Office of the European Union.

4. INFORMATION ABOUT THE RESEARCH LIMITATIONS

This research used statistical data reflecting both general economic indicators and transport performance indicators. Due to the objective lack of a complete set of statistical data for all EU countries over the last three years, only indicators for countries with a complete set of data were taken into account.

5. INFLUENCE OF MACROECONOMIC AND SECTORAL FACTORS ON THE VALUE ADDED PER EMPLOYEE IN THE TRANSPORT SECTOR

This research focuses on factors that influence the efficiency of the transport sector and that the government can influence. At the time of the study, the relevant indicators had already been shaped by policies adopted earlier by governments at the macro level and directly in the transport sector.

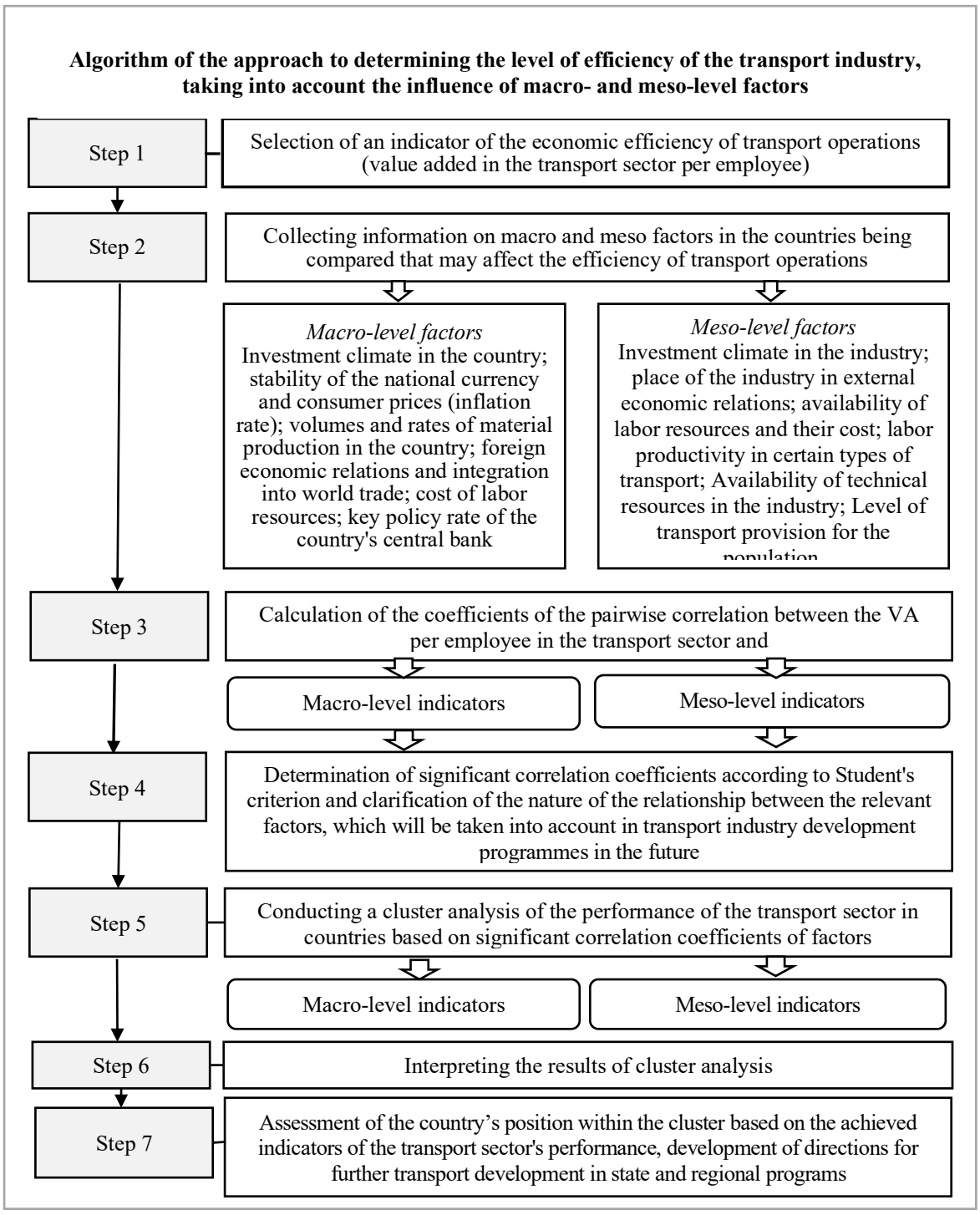

Fig. 2. Algorithm for the methodology for determining the level of efficiency of the transport sector, taking into account the influence of macro and meso-level factors. Source: own author’s idea

The following macroeconomic indicators were taken into account: 1) the investment climate in the country, 2) the stability of the national currency and consumer prices, 3) the volume and pace of production in the country, 4) the level of foreign economic activity, 5) the availability of labor resources, and 6) the monetary policy of the country's central bank. Among the factors affecting the transport sector, the following were taken into account: 1) investment climate in the transport sector (e.g., investment volumes, including foreign direct investment; number of enterprises in the sector and level of monopolism in the transport services market; tax incentives; 2) the development of transport infrastructure (road density, number of railway stations, airports, river and sea ports, terminals); 3) the activity of foreign economic operations in the sector (export, import of transport services); 4) the availability of labor resources in the transport sector; 5) average wages in individual types of transport; 6) labor productivity in individual types of transport; 7) indicators of the operation of rolling stock of individual types of transport (volumes of freight and passenger traffic, work performed in tonne-kilometres and passenger-kilometres); 8) availability of rolling stock for individual types of transport and its technical condition; 9) level of transport services for the population (number of passenger cars per thousand inhabitants). Table 1 presents the significant values of the correlation coefficients between macroeconomic and branch factors and the value added (VA) per employee in the transport branch.

Table 1

Significant values of the correlation coefficients of macroeconomic and branch factors with the VA per employee in the transport branch

Indicators	Significant correlation coefficients
Macroeconomic indicators	
Minimum wages, euros	0.91158
Total expenditure on social protection per head of population. ECU/EUR	0.89842
Air emissions intensities by NACE, gross (grams per euro, current prices)	-0.70902
EU direct investment positions by country, ultimate and immediate counterpart, and economic activity (Million EUR)	0.70711
Wholesale and retail trade turnover per person employed, thousand euros	0.70514
Corporate income tax,%	0.68852
Healthy life expectancy based on self-perceived health, years	0.61235
Annual index of inflation	-0.55689
Passenger cars - per thousand inhabitants	0.53420
Sectoral indicators	
Thousand passenger-kilometers per railway employee	0.91128
Average CO2 emissions, g per km, from new passenger cars	-0.86121
Fixed assets per employee in the branch, thousand euro	0.79862
Cargo transported by air per employee, ton	0.82121
Passengers transported by air per employee	0.77378
Density of inland waterways network, km per km^2	0.78201
Density of the road network, km per sq. km	0.66287
Passenger cars - per thousand inhabitants	0.67356
Thousand tonne kilometers traveled by road per employee	-0.62135

Source: created by the authors based on Eurostat data [https://ec.europa.eu/eurostat/web/main/data/database]

For the correctness of international comparison of the efficiency of the transport sector, it is necessary to divide the country into the corresponding homogeneous (homogeneous) groups according to the studied indicators. The most convenient classification methods include cluster analysis.

To measure the similarity of the country according to the studied indicators, which ensures the efficiency of the transport sector, the most extended unit of measure (i.e., Euclidean distance) was chosen. Objects with minimal distances are more similar to each other than objects with large distances. Euclidean distance (geometric distance in multidimensional space) was calculated according to the formula:

$$d_{ij} = \sqrt{\sum_{k=1}^{p} (x_{ik} - x_{jk})^2}, \quad (1)$$

where d_{ij} is the distance between objects i and j; x_{ik} is the value of the k-th variable for the i-th object.

Clustering can be performed using both hierarchical and non-hierarchical methods. Hierarchical methods involve the construction of a dendrogram (from the Greek dendron - "tree") - a tree-like diagram consisting of n levels, each of which corresponds to one of the stages of the cluster enlargement (separation) process.

Compared to other hierarchical methods, the average link and Ward methods show the best results [1]. Figs. 3 and 4 present dendrograms created based on selected indicators at the macro level and the transport sector level using the Ward method.

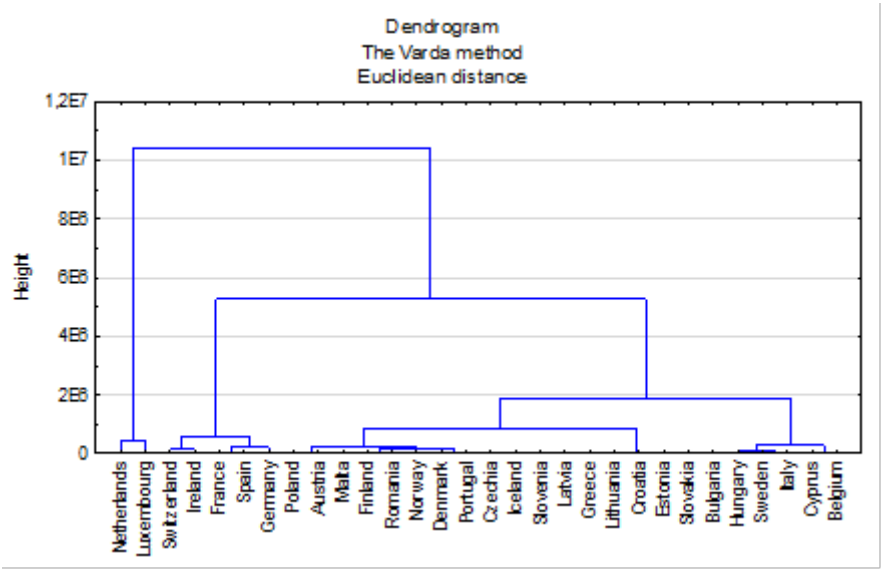

Fig. 3. Dendrogram created using the Ward method based on the macro-level indicators studied. Source: created by the authors based on data from https://ec.europa.eu/eurostat

The Varda method diagrams show four clusters of countries based on the efficiency of their transport sectors. Therefore, k-means clustering was performed for four clusters. Due to incomplete data in official transport performance statistics, some countries were excluded from the k-means clustering (Cyprus, Malta, Iceland). Table 2 presents the results of k-means clustering based on the macro-level indicators and transport sector indicators studied.

When considering sectoral factors, Denmark, Norway, and Belgium were also included in the first cluster. They are characterized by high fixed assets per employee in the transport sector, high volumes of road transport, and the lowest average CO_2 emissions per km from new passenger cars. In terms of other transport sector performance indicators, they lag behind the countries in the second cluster (Switzerland, Austria, France, and Sweden) and the third cluster (Ireland, Spain, Greece, Finland, Portugal, Germany, Slovenia, and Italy). These countries are characterized by a developed material and technical base (high value of fixed assets per employee in the transport sector) and large volumes of rail, road, and air transport. Average CO_2 emissions per km from new passenger cars are higher

than in the countries of the first cluster but lower than in the countries of the fourth cluster. The increase in harmful emissions into the atmosphere leads to a certain reduction in the life expectancy of the population of these countries. The fourth cluster is characterized by lower freight and passenger transport volumes, lower density of road and rail networks, and the highest Average CO_2 emissions from new passenger cars among the European Union countries studied.

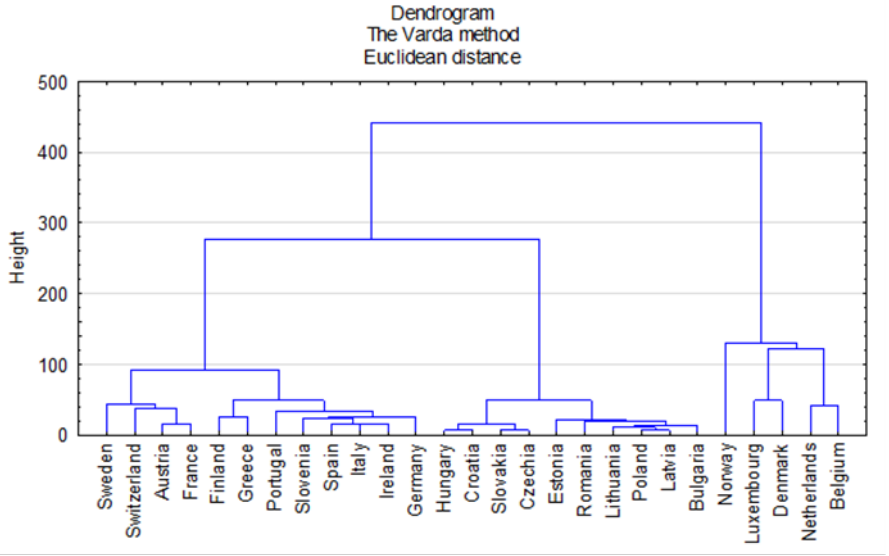

Fig. 4. Dendrogram created using the Vardy method based on indicators studied in the transport sector
Source: created by the authors based on data from https://ec.europa.eu/eurostat

Table 2

Distribution of countries by level of development of the transport sector according to the results of cluster analysis (2023)

Macroeconomic indicators				
Cluster 1 (2 countries)	Cluster 2 (5 countries)	Cluster 3 (5 countries)	Cluster 4 (18 countries)	
Luxembourg	Germany	Belgium	Bulgaria	Austria
Netherlands	Ireland	Italy	Czechia	Poland
	Spain	Cyprus	Denmark	Portugal
	France	Hungary	Estonia	Romania
	Switzerland	Sweden	Greece	Slovenia
			Croatia	Slovakia
			Latvia	Finland
			Lithuania	Iceland
			Malta	Norway

Sectoral indicators					
Cluster 1 (5 countries)	Cluster 2 (4 countries)	Cluster 3 (8 countries)		Cluster 4 (10 countries)	
Luxembourg	Switzerland	Ireland	Germany	Bulgaria	Poland
Denmark	Austria	Spain	Finland	Czechia	Romania
Netherlands	France	Greece	Portugal	Estonia	Slovakia
Norway	Sweden	Italy	Slovenia	Croatia	Lithuania
Belgium				Latvia	Hungary

Tables 3 and 4 show the average values of macroeconomic indicators and transport sector performance indicators for countries based on the results of cluster analysis.

Table 3

Average values of macro-level indicators for countries based on the results of cluster analysis (2023)

Indicators	Cluster 1 (2 countries)		Cluster 2 (5 countries)		Cluster 3 (5 countries)		Cluster 4 (18 countries)	
	Mean value	Std. dev.	Mean value	Std. dev.	Mean value	Std. dev.	Mean value	Std. dev.
Value added per employee, thousand euro	0.12	0.04	0.07	0.02	0.06	0.02	0.05	0.03
Total expenditure on social protection per head of population, euro	14.88	3.0	11.0	2.1	8.8	2.9	7.4	3.3
EU direct investment positions by country, Million euro	3387.13	311.71	992.71	200.5	419.99	84.3	96.6	47.7
Turnover and volume of sales in wholesale and retail trade, index, 2021=100	107.0	0.9	113.0	6.2	116.1	5.4	118.0	8.8
Corporate income tax,%	25.0	5.4	25.9	7.9	22.5	10.3	19.7	5.5
Healthy life expectancy based on self-perceived health, Year	78.0	0.1	77.3	2.9	75.7	3.3	72.4	4.1
Annual index of inflation	110.0	0.3	119.9	5.0	121.6	6.6	129.6	9.3

Source: created by the authors based on Eurostat data [https://ec.europa.eu/eurostat/web/main/data/database]

Table 4

Average values of sectoral indicators of countries according to the results of cluster analysis (2023)

Indicators	Cluster 1 (5 countries)		Cluster 2 (4 countries)		Cluster 3 (8 countries)		Cluster 4 (10 countries)	
	Mean value	Std. dev.	Mean value	Std. dev.	Mean value	Std. dev.	Mean value	Std. dev.
Value added per employee - thousand euros	0.12	0.03	0.08	0.01	0.05	0.01	0.03	0.00
Passengers transported (rail) (Millions of passenger-kilometers)	28.52	21.22	62.23	52.42	100.64	85.89	5.55	1.27
Average CO2 emissions, g per km, from new passenger cars	89.46	36.38	109.15	15.19	116.41	11.05	136.14	5.73
Fixed assets per employee in the branch, thousand euro	0.03	0.01	0.03	0.01	0.02	0.01	0.01	0.00

Air transport of goods by country (Tonne)	7.36	4.38	37.12	42.89	25.56	36.47	14.26	9.51
Air transport of passengers by country, passengers, thousand passengers	30.99	25.42	60.63	46.87	95.90	77.08	55.67	48.05
Density of the road network, km per sq. km	0.05	0.03	0.02	0.003	0.02	0.01	0.01	0.00
Passenger cars - per thousand inhabitants	0.55	0.08	0.54	0.04	0.57	0.07	0.48	0.08
Goods transported by road (Million tonne-kilometer)	859.8	647.9	716.2	580.88	919.64	775.46	69.56	50.62

The above table illustrates that macroeconomic factors shape the environment in which transport operates. However, the effectiveness of transport itself is directly influenced by the effectiveness of sectoral reforms and development programs implemented by national governments.

6. THE FORMATION OF THE STATE TRANSPORT POLICY BASED ON THE ANALYSIS OF THE ACHIEVED INDICATORS OF TRANSPORT EFFICIENCY

As already emphasized, transport development cannot be separated from the development of the country's economy as a whole. Therefore, the formulation of the state transport policy should take into account the country's situation, its socio-economic development prospects, and the current and target state of the transport industry (Figure 5).

Therefore, the model of the achieved indicators and efficiency of transport performance will take into account the influence of factors that the government cannot influence, as well as those determined by the effectiveness of its decisions in the general economic and sectoral plane:

$$R = f(X, C, D) \tag{2}$$

where R – achieved indicators of transport operation and efficiency; X – external factors that the government cannot influence; C – internal factors that the government cannot influence; and D - factors in the sphere of government decision-making on the development of the economy and individual sectors, including transport.

The model of targets and performance indicators for transport will also take into account those already achieved:

$$G = f(X, C, D, R) \tag{3}$$

where G – targets transport performance and efficiency.

Targets can be set by the government of the country, taking into account the best practices of other countries in its cluster. In the future, measures to achieve these goals should be coordinated with other areas of state policy, in particular with regional development policy, environmental protection, urban development and the promotion of material and production industries.

When identifying specific bottlenecks in ensuring the efficiency of the transport sector in a particular country, it is advisable, in our opinion, to conduct further cluster analysis within the cluster defined above. This will enable the government to assess the efficiency of the industry across countries with similar conditions and transport indicators. The information obtained can be used to develop a set of measures at the macroeconomic and sectoral levels in the course of formulating relevant development programs.

7. CONCLUSIONS

This paper offers a conceptual approach to assessing the economic efficiency of state transport policy, specifically by evaluating the efficiency of state transport policy through the achieved indicators of transport performance. Information on the achieved transport performance indicators enables the assessment of the efficiency of reforms in the transport sector and the identification of areas for improvement. It has been established that the economic efficiency of transport depends on factors that are formed at the macro level, as well as on existing transport operating conditions.

A generalized model for the formation of state transport policy based on the analysis of the achieved indicators of transport efficiency

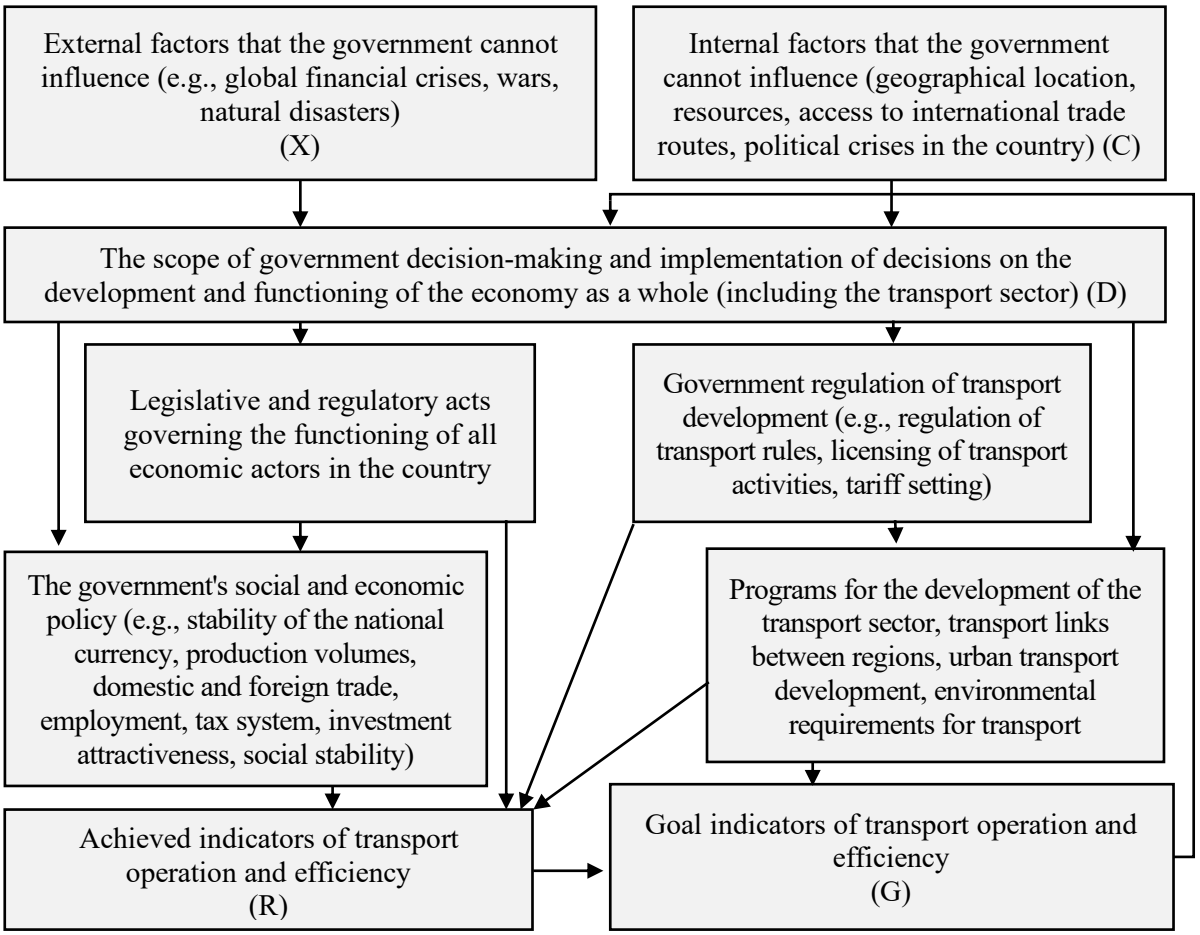

Fig. 5. A generalized model for the formation of state transport policy based on the analysis of the achieved indicators of transport efficiency. Source: own author's idea

The value added per employee in the sector has been proposed as an indicator of the economic efficiency of the transport sector. Macro-level and transport sector-level factors that influence the proposed efficiency indicator have been identified. Clustering countries according to these factors enables the identification of countries with similar transport efficiency indicators and the determination of areas for developing measures at the macroeconomic and sectoral levels aimed at improving transport performance. Macro-level and transport sector factors influencing the proposed performance indicator were identified. Clustering countries according to these factors allows for identifying countries with similar transport performance indicators and determining directions for

developing measures at the macroeconomic and sectoral levels aimed at improving transport performance.

A generalized model for the formation of state transport policy was presented based on the results of the analysis of the examined transport performance indicators. The obtained information should be used as a basis for formulating achievable targets, taking into account the best practices of the cluster countries for further development of transport development programs.

8. DIRECTIONS FOR FURTHER RESEARCH

Further scientific interest lies in the application of current research results to substantiate a set of measures at the macroeconomic and sectoral levels for the development of national transport programs.

References

1. Abdulhafedh, A. Incorporating K-means, hierarchical clustering and PCA in customer segmentation. *Journal of City and Development*. 2021. Vol. 3(1). P. 12-30. DOI: 10.12691/jcd-3-1-3.
2. Alhassan, J.A.K. & Anciaes, P. Public transport investments as generators of economic and social activity. *Journal of Transport & Health*. 2025. Vol. 41. No. 101989. DOI: 10.1016/j.jth.2025.101989.
3. Aminzadegan, S. et al. Factors affecting the emission of pollutants in different types of transportation: A literature review. *Energy Reports*. 2022. Vol. 8. P. 2508-2529. DOI: 10.1016/j.egyr.2022.01.161.
4. Bondar, N. & Gendek, S. & Karpenko, O. et al. Modeling of traffic flows in the justification of projects of road construction in conditions of concession. *Eastern-European Journal of Enterprise Technologies*. 2020. Vol 1. No. 4(103). P. 33-42. DOI: 10.15587/1729-4061.2020.193463.
5. Borges, A.M. & de Freitas Dourado, A.B. & de Andrade, M.O. & de Aragão, J.J.G. Regional development and transport infrastructure in the Brazilian amazon region: a literature review on governmental plans for the Transamazon Highway. *Transportation Research Procedia.* 2025. No. 82. P. 2262-2275. DOI: 10.1016/j.trpro.2024.12.185.
6. Heldt, P. Infrastructure development and its effects on transport, demography and employment: The example of a new rail line Dresden-Prague. In: *Spatial and transport infrastructure development in Europe: Example of the Orient/East-Med Corridor.* Hannover: Verlag der ARL-Akademie für Raumforschung und Landesplanung. 2019. P. 215-230. ISBN: 9783888380969.
7. Hörcher, D. & Tirachini, A. A review of public transport economics. *Economics of transportation*. 2021. Vol. 25. No. 100196. DOI: 10.1016/j.ecotra.2021.100196.
8. Huang, N. & Lien, J.W. & Zheng, J. To acquire or compete? Government intervention in transportation under different route structures. *Transportation Research. Part E: Logistics and Transportation Review*. 2023. Vol. 172. DOI: 10.1016/j.tre.2023.103033.
9. Ji, W. & Huang, Z. & Gao, G. & Zheng, P. Evaluation of integrated transport efficiency and equity at the county level-taking the counties in Ningbo city as an example. *Transport Policy.* 2024. No. 148. P. 257-272. DOI: 10.1016/j.tranpol.2024.01.011.
10. Karner, A. & Pereira, R.H. & Farber, S. Advances and pitfalls in measuring transportation equity. *Transportation*. 2024. Vol. 52. P. 1-29. DOI: 10.1007/s11116-023-10460-7.
11. Kopelias, P. & Demiridi, E. & Vogiatzis, K. et al. Connected & autonomous vehicles – Environmental impacts – A review. *Science of the Total Environment*. 2020. Vol. 712. No. 135237. DOI: 10.1016/j.scitotenv.2019.135237.
12. Litman, T.M. Evaluating transportation equity: Guidance for incorporating distributional impacts in transport planning. *Institute of Transportation Engineers. ITE Journal*. 2022. Vol. 92. No. 4. P. 43-49.

13. Liu, Y. & Ali, A. & Chen, Y. & She, X. The effect of transport infrastructure (road, rail, and air) investments on economic growth and environmental pollution and testing the validity of EKC in China, India, Japan, and Russia. *Environmental Science and Pollution Research*. 2023. Vol. 30(12). P. 32585-32599. DOI: 10.1007/s11356-022-24448-w.
14. O'Sullivan, P. & Holtzclaw, G.D. & Barber, G. *Transport network planning*. Routledge. 2022. DOI: 10.4324/9781003182993.
15. Paulus, T.A. Europe's freight transport policy: analysis, synthesis and evaluation. In: Yoram, S. & Kamargianni, M. (eds.) *Advances in Transport Policy and Planning*. Academic Press 2018. Vol. 1. P. 197-243. Available at: 10.1016/bs.atpp.2018.07.006.
16. Profillidis, V.A. & Botzoris, G.N. Transport demand and factors affecting it. In: Profillidis, V.A. & Botzoris, G.N. (eds.) *Modeling of Transport Demand*. Elsevier. 2019. P. 1-46. ISBN: 9780128115138. DOI: 10.1016/B978-0-12-811513-8.00001-7.
17. Qin, Z. & et al. Externalities from restrictions: examining the short-run effects of urban core-focused driving restriction policies on air quality. *Transportation Research Part D: Transport and Environment.* 2023. Vol. 119. No. 103723. DOI: 10.1016/j.trd.2023.103723.
18. Ruiz-Padillo, A. & de Oña, J. Analysis of the relationships among infrastructure, operation, safety, and environment aspects that influence public transport users: Case study of university small and medium sized cities in Brazil. *Transportation Research Part A: Policy and Practice.* 2024. Vol. 185. No. 104115. DOI: 10.1016/j.tra.2024.104115.
19. Samunderu, E. Africa's air Transport infrastructure: Challenges, complexities and opportunities. In: *African air transport management: Strategic analysis of African aviation market*. Cham: Springer International Publishing. 2023. P. 151-187. DOI: 10.1007/978-3-031-29324-5_5.
20. Scholl, B. & Peric, A. & Niedermaier, M. (eds.) *Spatial and transport infrastructure development in Europe: Example of the orient/east-med corridor.* BoD-Books on Demand. 2020. Vol. 12. P. 215-230. ISBN: 978-3-88838-095-2.
21. Solomon, A. & Terefe, H. & Woldetensae, B. Gaps in failure management of public transport supply in Addis Ababa: a comprehensive assessment. *Urban, Planning and Transport Research*. 2025. Vol. 13(1). No. 2493104. DOI: 10.1080/21650020.2025.2493104.
22. Tang, K.H.D. Climate change policies of the four largest global emitters of greenhouse gases: their similarities, differences and way forward. *Journal of Energy Research and Reviews*. 2022. Vol. 10. No. 2. P. 19-35. DOI: 10.9734/JENRR/2022/v10i230251.
23. Zhang, Ch. et al. Linkage mechanism of public transport subsidy: considering passenger ridership, cost, fare and service quality. *Transportation Letters*. 2023. Vol. 15. No. 8. P. 941-956. DOI: 10.1080/19427867.2022.2113280.
24. *Zhang*, Y. & Cheng, L. The role of transport infrastructure in economic growth: Empirical evidence in the UK. *Transport Policy*. 2023. Vol. 133. P. 223-233. DOI: 10.1016/j.tranpol.2023.01.017.
25. Żaboklicka, E. Critical infrastructure in the shaping of national security. *Security and Defence Quarterly.* 2020. Vol. 28. P. 70-81. DOI: 10.35467/sdq/118585.

Received 10.09.2023; accepted in revised form 13.06.2025