РОЗВИТОК ПРОДУКТИВНИХ СИЛ І РЕГІОНАЛЬНА ЕКОНОМІКА

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Karpenko H.Y., Junior Researcher,
Institute for Market Problems and Economic and Ecological Research of the NAS of Ukraine

DIRECTIONS OF REGIONAL TRANSPORT INFRASTRUCTURE DEVELOPMENT

Karpenko H.Y. Directions of regional transport infrastructure development. The article presents the author's vision of theoretical and methodological approaches to the assessment of transport infrastructure in terms of their impact on the development of regions. The scientific-theoretical and applied aspects of solving the problems of regional development taking into account the infrastructure component are analysed and summarized. The acutest problems are highlighted and the author's approach to their solution is suggested. The application of the criterion of transport accessibility for determining the effectiveness of using the transport infrastructure of the region is justified. A methodological tool for assessing the level of transport accessibility of the region is offered.

Key words: regional development, transport infrastructure, transport accessibility.

Карпенко Г.Ю. Напрямки розвитку регіональної транспортної інфраструктури. В статті представлено авторське бачення теоретичних та методичних підходів до оцінки транспортної інфраструктури з точки зору їх впливу на розвиток регіонів. Проаналізовані та узагальнені науково-теоретичні та прикладні аспекти вирішення проблем розвитку регіонів з урахуванням інфраструктурної складової. Відокремлені найбільш гострі проблеми та запропоновано авторський підхід до їх вирішення. Обґрунтовано використання критерію транспортної доступності для визначення результативності використання транспортної інфраструктури регіону. Запропоновано методичний інструментарій оцінки рівня транспортної доступності регіону.

Ключові слова: регіональний розвиток, транспортна інфраструктура, транспортна доступність.

Карпенко Г.Ю. Направления развития региональной транспортной инфраструктуры. В статье представлено авторское видение теоретических и методических подходов к оценке транспортной инфраструктуры с точки зрения их влияния на развитие регионов. Проанализированы и обобщены научно-теоретические и прикладные аспекты решения проблем развития регионов с учетом инфраструктурной составляющей. Выделены наиболее острые проблемы и предложен авторский подход к их решению. Обосновано применение критерия транспортной доступности для определения результативности использования транспортной инфраструктуры региона. Предложен методический инструментарий оценки уровня транспортной доступности региона.

Ключевые слова: региональное развитие, транспортная инфраструктура, транспортная доступность.

Formulation of the problem. In modern conditions, one of the key factors in the development of regions is an effectively functioning infrastructure, which is an element of their livelihoods and that ultimately determines the quality of life of the population. Current trends of development indicate that the production of goods needed by society for conducting various activities requires a constant increase in the efficiency of the infrastructure complex transport and is the most important element of the infrastructure, therefore, the key direction of increasing the efficiency of social production is the formation of transport infrastructure that promotes the development of regions through the provision of high-quality transport services to ensure connectivity of space. The practice of recent years has shown that regions with higher transport access to material, natural resources and markets tend to have a higher level of development, now in regions, a balanced development of all available modes of transport is provided only in limited cases. However, new modern challenges, when investment resources become less accessible, and the cost of other resources is rather unstable, the problems of regional development depend crucially on activating the potential of all modes of transport on the principles of realizing their competitive advantages and multimodality.

Analysis of recent research and publications. When studying the problems of regional management, the tasks of forming and developing the transport infrastruc-

ture, there are scientific and applied results of the work of such scientists as Vlasyuk O. (1), Hudyma R. (2), Emelyanova O. (3), Kitchenko V. (4), Kondratiev V. (5) Kopytko V. (6), Kuznetsova A. (7), Preyger D., Sobkevich A. (8), Sokolova O. (9), Shyba O. (10) and many others. The existence of such a large number of studies only confirms the complexity, the relevance of solving problems related to the functioning and development of transport infrastructure, its relevance to the work of all sectors of the national economy, an important condition for improving the quality of life of the population. Nevertheless, given the capital-intensive nature of the transport infrastructure, research in this subject area is focused primarily on the use of extensive development factors. A number of theoretical and applied issues of socio-economic development of regions based on the activation of transport infrastructure factors and the subsequent receipt of sectoral and non-sectoral effects have not yet been fully resolved.

Identification of unsolved earlier parts of a common problem. The success of the functioning of regional socio-economic systems largely depends on certain conditions that ensure the possibility of effective development of material production and social life [2; 11]. A key role in the formation of such conditions is played by the regional infrastructure tied to the service of a certain territory and, therefore, located in close interconnection with it. On the one hand, the realization of the region's economic potential imposes certain requirements on the functioning infrastructure; on the other hand, the opportunities provided by the infrastructure lead to an adjustment of priorities and directions for further socio-economic development of the region. Therefore, issues of harmonious regional development in one way or another affect the need for the development of regional infrastructure.

One of the most important elements of the overall infrastructure of the region is the transport infrastructure [10; 12; 13]. There are a number of approaches to its definition, the position of the authors of which is related to the profile of their scientific interests at the present time. For example, in economic theory, the international transport system is an essential element of the global infrastructure. In the national economy, the country's transport infrastructure includes the rolling stock and the ways of communicating the territories. In the regional economy, transport is referred to complementary infrastructure industries in the region [9; 14].

In turn, normative documents are dominated by the approach within the industry. In our opinion, when considering the organizational and economic factors of territorial development, one should not confine ourselves to a purely sectoral approach to the content of the transport infrastructure, not taking into account the fact that transport contributes to the organization of the economic space, providing a spatial division of labour and the continuity of the reproductive processes, as well as the possibility of obtaining a multiplicative effect due to complex interdependence of various sectors of the economy.

We propose to consider the transport infrastructure as a subsystem of the regional economic system that establishes institutional links and provides transport services to both the regional economy and the population. In connection with this, the purpose of this article is to formulate theoretical provisions on the factors and directions for the development of the regional transport infrastructure in the current context.

Exposition of the main material of the study. The creation of a system of measures for the organizational and economic development of the transport infrastructure cannot be limited to the possible use of transport accessibility indicators, since in any case it is difficult to cover the existing set of factors that have a significant impact on the functioning of the territorial transport system of regions in connection with their economic development. An example of the ambiguous relationship between the level of transport accessibility and the economic development of territories can be the results of the study presented in [15], where three types of areas of Western Europe are identified: One of the key problems remaining in the focus of theory and practice of economic development of territories is an effective organization economic space.

In the process of adopting complex integrated solutions, which include planning for the development of transport infrastructure, it is necessary to take into account numerous and often contradictory factors. At the same time, heuristic methods can be used, based on expert intuitive-logical conclusions and methods of finding a solution by using mathematical procedures [16; 17; 18; 19]. An important characteristic of the first group of methods is the possibility of intuitively evaluating those factors that are difficult and sometimes impossible to describe with the help of exact dependencies. The second group of methods, called optimization, is focused on choosing the best alternative from all the conditions of the problem.

At the same time, most often the issues of planning the transport infrastructure were considered in the context of the overall development of one or a group of economic regions. This approach is valid in a methodical sense but, in this case, the size of tasks turned out to be very significant, which led to the need for the practical implementation of them to the decomposition of models and, as a consequence, shifting the emphasis to production factors to the detriment of infrastructure.

Since the task of transport development of the territory is an example of optimization of complex systems, it is proposed to use three targets (criteria):

1. Minimizing the costs of transport communications, transportation of goods and passengers in the region (cost criterion):

$$\sum_{i\epsilon I}\sum_{j\epsilon J} C_{ij} * \sum_{n\epsilon N}\sum_{z\epsilon Z} R_{zn} * Y_{zn} \rightarrow min. \qquad (1)$$

2. Minimizing the delivery of cargo and passengers (time criterion):

$$\sum_{i\epsilon I}\sum_{z\epsilon Z} H_{zn} * Y_{zn} \rightarrow min. \qquad (2)$$

3. Maximization of the quality parameters of the freight and passenger transportation process (criterion of quality of transport services):

$$\sum_{n\epsilon N}\sum_{z\epsilon Z} B_{zn}^{*}\ Y_{zn} \rightarrow max. \qquad (3)$$

where i – transport communication type index (taking into account the infrastructure), i is I, where I – a set of indices i;

j – a sign of the state of transport communication, j is J, where J – a set of indices j;

z – vehicle type index (rolling stock), z is Z, where Z – a set of indices z;

n – vehicle condition indicator, n is N, where N – a set of indices n;

X_{ij} – length of transport communications i-th type of transport, relating to the j-th sign of their condition, km (units);

Yzn – number of vehicles z-th type, relating to the n-th sign of their condition, units;

C_{ij} – annual maintenance cost (costs) units of transport communication i-th type, relating to the j-th sign of their condition, UAH;

R_{zn} – annual transportation costs (transportation costs), per unit of rolling stock z-th type, relating to the n-th sign of their condition, UAH;

H_{zn} – the urgency of the delivery of goods and passengers z-th type of transport, relating to the n-th – a sign of its condition (reflects the relative speed of movement of cargo through the transport network);

B_{zn} – grade assessment of the quality of delivery of goods and passengers z-th type of the transport, relating to the n-th – a sign of its condition, points (is determined by an expert method).

With the introduction of the above symbols, the following interpretation was adopted.

The type of transport communication is understood as an element of the transport infrastructure of the following modes of transport: automobile, railway, water, air, pipeline. Examples of types of transport communication can be considered:

- for road transport: unpaved highways, paved roads and highways in conjunction with road infrastructure
- for railway transport: public railway lines, high-speed railways, including relevant infrastructure;
- for water transport: sea and river routes, canals, floodgates, and other infrastructure facilities for water work;
- for air transport: air corridors and ground infrastructure for this mode of transport;
- for pipeline transport: oil pipelines, gas pipelines, including relevant infrastructure.

The state of transport communication is understood as its ability to perform its main function, either without additional financial investments (only funds are required to maintain the operability of the facilities), or with the financing of modernization and/or technical reconstruction, or the need to build a new transport route (section).

When calculating the length of transport communications, the following is accepted as a unit of measure: for road transport – 1 km of one lane of the road; for railway transport – 1 km of single-track railway; for water transport – 1 km of waterway provided with navigable conditions and dimensions for safe navigation of traditionally used transport vessels; for air transport – 1 km of the flight strip; for pipeline transport – 1 km of pipeline line.

The value of the maintenance of the unit of transport communication includes:

- directly annual expenses to maintain the communication routes;
- the costs of ensuring the operation of the relevant infrastructure facilities (transport facilities, parking spaces, washing, security lanes, etc.).

The annual transportation costs per unit of rolling stock are calculated taking into account the initial and final operations and operations in the way (loading (landing), unloading (disembarking), shipping, pause, processing of documents, etc.).

A specific variant of the organization of the transportation process is multimodal transport when two or more types of transport are included in the transport process. In this case, when forming the parameters of the problem to be solved (costs, terms, quality of transport), they should be defined as a whole on a specific line as a final rating for all modes of transport involved. At the same time, if the costs and time are amenable to simple summation within the framework of the design matrix, then the quality of the transport service as a whole on the line (B_l) can be determined by the formula:

$$B_l = \sum_{z\epsilon Z_l}\sum_{n\epsilon N} B_{zn}^{*}\ (t_z / \sum_{z\epsilon Z_l} t_z), \qquad (4)$$

where B_l – grade assessment of the quality of delivery of goods and passengers z types of transport, related to n-th sign of their condition, and included in l-th modal line; z is Z_l, where Z_l is the subset of z indices corresponding to the inclusion of the transport modes reflecting them into the l th modal line,

t_z – the time spent by z-th mode of transport for transportation in l-th module line, day.

As constraints (conditions for the achievement of optima), the following:

1. The volume of transported goods and passengers in a certain territory, both on departure and on arrival, must be in a range that ensures the demand of the population and the business community for the work of transport (for example, on the basis of interbranch regional balance); It is possible to differentiate the volumes of transportation both by mode of transport and by certain types of vehicles.

2. The number of units by type of rolling stock in the territory should be in the interval corresponding to its effective operation, provided that there are reasonable reserves, which allow minimizing the waiting time for both the delivery of goods and passengers and their arrival; In excess of vehicles, transport units should be transferred to areas that are experiencing a deficit, and in case of inadequate own transport, use unused rolling stock from other areas or justify orders for its production.

3. The amount of investment in modernization, construction of new, repair and operation of transport communications should not exceed the possibility of the territory at the expense of all sources of financing; while private restrictions on the size of investments by modes of transport and on certain types of transport communications are possible, especially in the framework of large projects included in targeted programs at the federal or regional levels.

4. Investments in rolling stock by types of transport, types of vehicles should correspond to the resource capabilities of transport enterprises; these investments can be differentiated in the areas of renewal of rolling stock: modernization, capital repair, the acquisition of a new rolling stock.

The presence of three target benchmarks leads to the need to solve a multicriteria problem. Problems of this type are solved using a number of specific approaches, one of which is the threshold optimization method [20]. In comparison with other possible methods (Pareto optimality determination, supercritical allocation), this method has the possibility of simultaneous use of different sizes in the conditions of both current and prospective planning and management.

The method consists of the following main steps:

- a solution of optimization problems separately for each of the selected criteria with the detection of extreme levels of the values of the criteria;
- the establishment of threshold values of criteria with the help of experts;
- the introduction of additional constraints with threshold values into the condition of the problem with respect to a number of criteria with the subsequent solution of the problem on a criterion free from constraints.

The results of the modelling determine the framework conditions for the development of the transport infrastructure in the region. The final decisions on infrastructure development form regional and interregional projects.

The specificity of transport projects is their social nature, as they are usually implemented in full or in part at the expense of budgetary sources of financing. The analysis of the world experience in the evaluation of transport projects in the case of the countries of the EU, North America, Japan, Australia, New Zealand, South Africa and a number of international organizations [21] made it possible to make a fundamentally important conclusion that the effectiveness of such projects is not primarily considered purely commercial, but from a public position.

The reason for the spread of this approach is that the approach to assessing the effectiveness of transport has now changed. If earlier indicators were used as a basis for the volume of transport work (mileage of the rolling stock, the given location-kilometres, etc.), now the leading places are those related to meeting the needs for transport services: the time of the trip, the speed of delivery, number of points to be connected by routes, etc.

It is advisable to closely link the strategy of transport infrastructure development with optimizing the costs of maintaining the required level of transport accessibility. Taking into account the foregoing, the author proposes to use the resulting indicator when deciding on the development of transport systems and their corresponding transport infrastructures – the ratio of the growth factor of transport accessibility indicators to the investment growth ratio:

$$S = \frac{K_p}{K_i}, \quad (5)$$

where S – estimated value of project decisions;

K_p – the resulting growth factor of transport accessibility indicators;

K_i – coefficient of investment growth.

The resulting growth rate of transport accessibility indicators can be determined by the formula:

$$K_p = \frac{K_{pn}}{K_{po}}, \quad (6)$$

where K_{pn} – the resulting coefficient of growth in the indicators of transport accessibility of direct influence (in our case: the carrying capacity of the transport system per day, the number of flights of the rolling stock taking into account the possible dispatch of passengers during the day, the number of settlements covered by the route, the level of comfort);

K_{po} – the resulting growth factor of transport accessibility indicators of the reverse effect (in our case: the fare, the average travel time).

It should be noted that the study did not address the issue of distributing traffic across the network, taking into account the patterns of user behaviour. And the preferences of individual client groups regarding the use of certain types of transport can influence the adoption of investment decisions, especially with regard to passenger transportation. It is obvious that in transport projects, the preferences of transport market subjects can also be taken into account as indicators of transport accessibility by analogy with the parameters presented above.

Conclusions. As a result of the analysis of the currently available indicators of transport accessibility, it is revealed that in the majority of cases they assess the state of the transport infrastructure, not allowing assessing the degree of its use. Therefore, a new complex indicator of the transport accessibility of the territory is proposed, the level of which has a close relationship with GRP levels and the number of employed population.

Since the final decisions on the development of the transport infrastructure as a part of the territorial transportation systems are determined in the development of relevant regional projects, a method is developed for calculating the socio-economic efficiency of such projects by comparing the growth rates of transport accessibility parameters and investment growth rates.

References:

1. Vlasyuk O.S. (2006). Zabezpechennya konkurentospromozhnosti ekonomiky rehioniv Ukrayiny v konteksti yevropeys′koyi intehratsiyi [Ensuring the competitiveness of the economy of the regions of Ukraine in the context of European integration]. Vestnik L'vovskoy kommercheskoy akademii Seriya ekonomichna - Bulletin of the Lviv Commercial Academy. Economic 23, 3–6 [in Ukrainian].

2. Hudyma R. (2014). Modernizatsiya transportnoyi infrastruktury prykordonnykh rehioniv: finansovi ta upravlins′ki aspekty [Modernization of the transport infrastructure of the border regions: financial and management aspects]. Visnyk L′vivs′koyi komertsiynoyi akademiyi. Seriya ekonomichna – Bulletin of the Lviv Commercial Academy. Economic ser., 46, 72–75 [in Ukrainian].

3. Sobkevych O. Shchodo perspektyvnykh napryamiv spivrobitnytstva Ukrayiny z krayinamy YES u realizatsiyi potentsialu transportnoyi systemy Ukrayiny [Concerning the promising directions of sprawling of Ukraine with the EU countries in realizing the potential of the Ukrainian transport system]. (n.d.). http://www.niss.gov.ua [in Ukrainian].

4. Kitchenko V. Strukturnyy instrument dlya infrastrukturnykh proyektov [Structural tool for infrastructure projects] Retrieved from http://www.rcb.ru/ol/2012-01/17490/ [in Russian].

5. Kondratiev V. Infrastruktura kak faktor ekonomicheskogo rosta [Infrastructure as a factor of economic growth] Retrieved from http://www.persektivy.ingo/print.php?ID=67861 [in Russian].

6. Kopytko V. Napryamy rozvytku transportnoyi infrastruktury Ukrayiny [Directions of development of transport infrastructure of Ukraine]. Retrieved from http://eadnurt.diit.edu.ua/bitstream/123456789/1613/1/905kopyt.pdf [in Ukrainian].

7. Kuznetsova A. (2006). Infrastruktura. Voprosy teorii, metodologii i prikladnyye aspekty infrastrukturnogo obustroystva. Geoekonomicheskiy podkhod [Questions of theory, methodologies and applied aspects of infrastructure development. Geoeconomic approach] [in Russian].

8. D.K. Preyger, O.V. Sobkevich, O.Yu. Єmelyanova (2001). Realizatsiya potentsiala transportnoy infrastruktury Ukrainy v strategii postkrizisnogo ekonomicheskogo razvitiya [Realization of the potential of Ukraine's transport infrastructure in the strategy of post-crisis economic development]. Kiev NISS [in Ukrainian].

9. Sokolova O.Ye. (2010). Teoretyko-metodolohichni osnovy formuvannya transportno-lohistychnoyi systemy Ukrayiny [Theoretical and Methodological Principles of the Formation of the Transport and Logistic System of Ukraine]. Problemy pidvyshchennya efektyv-nosti infrastruktury: zb. nauk. prats – Problems of Improving the Efficiency of Infrastructure: Sat. sciences works, (Vol. 27), (p. 258). Kiev. NAU, [in Ukrainian].

10. Shyba O.A. (2016). Vzayemozv″yazok rozvytku transportnoyi infrastruktury ta ekonomichnoho zrostannya [Interconnection of the development of transport infrastructure and economic growth]. Visnyk L′vivs′koho universytetu. ser. Mizhnarodni vidnosyny – Bulletin of the University of Lviv. ser. International Relations, 39, 286–296, [in Ukrainian].

11. Narolina T.S. & Preobrazhensky B.G. (2008). Effektivnoye upravleniye kak usloviye povysheniya konkurentosposobnosti regiona [Effective management as a condition for increasing the competitiveness of the region] Region: sistemy, ekonomika, upravleniye – Region: systems, economics, management 1, 129–130, [in Russian].

12. Gasilov V.V., Sapronov A.F. & Shibaeva M.A. (2011). Vliyaniye modernizatsii regional'noy dorozhnoy infrastruktury na sotsial'no-ekonomicheskoye razvitiye regiona [Influence of modernization of regional road infrastructure on social and economic development of the region]. Sovremennaya ekonomika: problemy i resheniya – Modern economy: problems and solutions, 7(19), 34–43, [in Russian].

13. Ivanov M.V. (2015). Transportnaya sistema i transportnaya infrastruktura: vzaimosvyaz' i faktory razvitiya [Transport system and transport infrastructure: the relationship and development factors]. Ekonomika i predprinimatelstvo. – Economics and Entrepreneurship, 12 part 2 65–2, 418–422 [in Russian].

14. Shvetsov A.N. (2011). Metodologiya i praktika issledovaniy territorialnykh sistem [Methodology and practice of research of territorial systems]. Region: ekonomika i sotsiologiya – Region: Economics and Sociology, 2, 292–297 [in Russian].

15. Schurmann C., Spiekermann K. & Wegener M. (1997). Accessibility Indicators. Deliverable D5 of Project Socio-Economic and Spatial Impacts of Transport Infrastructure Investments and Transport System Improvements (SASI) commissioned by the General Directorate VII (Transport) of the European Commission as part of the 4th Framework Programme of Research and Technology Development. The Institute of Spatial Planning of the University of Dortmund [in Eglish].

16. Preger D. Sobkevich O. & Yemelianov O. (2011) Realizatsiya potentsialu transportnoyi infrastruktury Ukrayiny v stratehiyi postkryzovoho ekonomichnoho rozvytku[Realization of the potential of the transport infrastructure of Ukraine in the strategy of post-crisis economic development]. p. 37, Kiev NISS [in Ukrainian].

17. Bondarenko V.M. (2013) Metodoloho-praktychni osnovy formuvannya ta vykorystannya sukupnoho resursnoho potentsialu rehionu: problemy ta perspektyvy [Methodological and practical bases of formation and use of aggregate resource potential of the region: problems and perspectives]. Candidate's thesis. Kiev [in Ukrainian].

18. Momot T.V., Ovyechkina O.A. & Abass K. Dzhaud (2014) Osnovni pidkhody do vyznachennya resursnoho potentsialu terytorial′no-vyrobnychykh kompleksiv rehionu [The main approaches to determining the resource potential of the region's industrial complexes]. Problems of social and economic development of business: Collective monograph. (pp. 72–78) Publishing house «BREEZE», Montreal, Canada [in English].

19. Shkola I.M. (Eds.) (2013). Transformatsiyni protsesy ekonomiky Ukrayiny v rehionalnomu vymiri [Transformation processes in the economy of Ukraine in the regional dimension]. Chernivtsi: Knyhy – XX [in Ukranian].

20. Troyanovsky Yu.A. (2000). Matematycheskoe modelyrovanye v ekonomyke [Mathematical Modeling in Economics]. Moscow: Unity [in Ukranian].

21. Prokhorova V.V., Slastyanikova A.I. (2012). Krytychnyy ohlyad metodolohichnykh pidkhodiv do otsinky resursnoho potentsialu promyslovoho pidpryyemstva v suchasniy ekonomitsi [A critical review of methodological approaches to assessing the resource potential of an industrial enterprise in a modern economy]. Ekonomika i upravlinnya – Economics and Management 5, 22–27 [in Ukranian].