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ОБОСНОВАНИЕ ПАРАМЕТРОВ ИНФРАСТРУКТУРЫ ЛОГИСТИЧЕСКОГО ОПЕРАТОРА

Представлена экономико-математическая модель, которая позволяет для транспортно-экспедиторской компании определять перспективы ее присутствия на рассматриваемых региональных рынках в качестве логистического оператора. Эта модель также позволяет устанавливать в процессе развития новые рынки для того, чтобы выступать в качестве составляющей логистической инфраструктуры регионов.

Ключевые слова: логистическая инфраструктура регионов, логистический оператор, материальный поток, транспортно-экспедиторская компания.

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INFLUENCE OF FEATURES OF THE TRANSPORT NETWORK PATTERN ON THE HAUL CYCLE LENGTH BETWEEN ITS NODES ON THE EXAMPLE OF THE TRANSPORT NETWORK OF UKRAINE

Досліджено сучасні підходи щодо визначення впливу параметрів та малюнку дорожньої мережі на ефективність функціонування транспорту. Встановлено, що параметри міжобласних перевезень залежать від характеристик дуг та загального малюнку дорожньої мережі. Визначено поняття коефіцієнту прямолінійності дослідженої дорожньої мережі та розраховано його значення для дослідженої мережі.

Ключові слова: *дорожня мережа, ефективність транспортного процесу, коефіцієнт прямолінійності мережі.*

1. Introduction

Ensuring the stable functioning of passenger transport systems can be considered a priority for organizers of transport and carriers. In the case that passengers are provided with the opportunity to realize the need for moving in the most convenient way, it is the basis for maximum implementation of potential transport correspondence between the nodes of the transport network. The main factors that affect the actual indicators of passenger traffic between the nodes of the transport network include:

- potential correspondence;
- fare;
- haul cycle time;
- time of day of haul cycle;
- haul cycle comfort;
- regularity and frequency of the haul cycle;
- social and economic characteristics of population development in transport hubs.

It can be noted that the actual indicators of passenger traffic volumes need to be adjusted to take into account the characteristic seasonal or daily fluctuations.

In turn, the intercity passenger route transport system uses its monetary resources to ensure its activities. The planned arrival of a monetary resource to ensure the stable functioning and development of intercity passenger route transport systems is indisputably important. At the same time, the distribution of money flows between elements of the transport system in time and quantity is no less relevant. In conditions of a balanced flow of financial flows within the system, the quantitative sufficiency of this resource and its balanced use of the elements of the system, it is possible to plan and develop the industry as a whole.

2. The object of research and its technological audit

The object of research is the state transport network on the example of Ukraine. This research examines the network of roads, which formed a modern transport network. The considered road network consists of more than 70 thousand arcs and nodes, which describe the routes of inter-regional, regional, international and regional significance.

This provided an opportunity in the invention of short variants of combinations of network nodes.

One of the most problematic places is quality improvement of transport performance. For the most part, scientists considered the optimization of traffic schedules, the choice of rolling stock and invented optimal routes [1, 2]. The transport network is a composite transport system and provides the ability to transport goods and passengers between its nodes. Along with this, the properties of the transport network affect the overall performance of the transport process, namely: the density and intensity of the flow of vehicles, the speed of the connection, the haul cycle length.

3. The aim and objectives of research

The aim of research is determination of the influence of the features of the transport network pattern on the haul cycle length between its nodes.

To achieve this aim, it is necessary to solve the following tasks:

1. To propose an approach to determining the quality score of the transport network pattern.
2. To evaluate the effectiveness of the existing road network by defining the concept of the straightness coefficient and its calculation for the selected network.

4. Research of existing solutions of the problem

At this stage of development of scientific approaches to the determination of the parameters of transport functioning, many different approaches have been proposed [3]. It is determined in [4] that the availability of passenger transport correspondences has a significant impact on the state of social and economic development of the society. Dependence of transport correspondence on routes taking into account social components is mathematically described. In work [5] the question of modeling of intercity passenger transport system is solved. In certain works, the distance traveled by the nodes of the transport network is a factor in the resistance to the realization of potential correspondence between cities.

The author of [6] considers the factors influencing the formation of the cost of rail freight. It is determined that the haul cycle length of the cargo convoy in direct proportion increases the transportation costs. The study of the cost price and the cost of rail transportation are also disclosed in [7], in which the author determines the need to reduce the lengths of the technological race of cars and the composition to reduce the cost of implementation, both passenger and freight traffic.

In [8], the authors define how the transport infrastructure is a transport network that consists of nodes and arcs. It is determined in [9] that the model of the transport network is aimed at describing transport communications (roads and railways, waterways and air routes) as a bound graph. At the same time, the authors establish that the route network consists of nodes and arcs, and sometimes contains routes. Drawing on such conclusions, the authors of [9] propose the description of nodes by points, arcs – polylines and realize such models with the help of geographic information systems. In work [10] the solution of a problem of modeling of transport processes, which, among other things, is based on the graph theory applied to road networks, is given. In this case, the intersection, the end and the beginning of the arcs (streets) are considered as nodes, and the actual distance between the nodes – the boundaries of the graph is taken as the graph size.

In work [11] the solution of the question on the analysis of transport networks through the application of geoinformation technologies is proposed and implemented. The authors of [12] study the results of examining modern information systems used in engineering networks. In their opinion, modern systems for use in working with engineering networks are computer-aided design systems and geoinformation systems. They found their place for the application of geoinformation systems in the analysis of transport networks and in the work of the authors [13]. As a result of their research, the authors determine the effectiveness of integrating mathematical methods of graph analysis with geoinformation systems for transport network planning and traffic management. In work [14] questions of application of geoinformation systems for the decision of problems of an estimation of transport maintenance of region are considered. The author of [15] estimates the impact of the transport network development on the economic development of the region, and in [16] the issue of providing an assessment of the impact of transport infrastructure on the socio-economic development of the region is resolved. Based on the results of the study, the author of [17] obtains a conclusion about the prospects for implementing mathematical methods of graph reduction by means of GIS in the planning of transport networks. In [17], the authors, using GIS tools, considered the question of estimating the pattern of a city route network by determining the total network length in a square kilometer.

Based on the results of the analysis, it has been established that the question of determining the influence of the parameters of road networks on the economic and social situation of the regions has not been sufficiently studied at present. The question of determining the quality of the road network pattern and the correspondence of the existing patterns to the optimal ones has also not been fully explored.

5. Methods of research

To determine the indicators of the efficiency of road networks, the impact of the road network development on social and economic indicators, it is suggested to use methods of system analysis. The actual state of the road networks development is proposed to be determined with the interruptions of the means of geoinformation systems on the example of Ukraine.

The author of [17] determines the road network density as its main indicator. The calculation of the total public transportation costs according to (1) is proposed.

$$C_{PH}HT^{ST}+C_c\delta F_r=Z\rightarrow \min, \quad (1)$$

where C_{PH} – the hour cost of transport time, UAH/hour; Z – total public transportation costs, UAH; H – number of haul cycles per year, units; S_c – the cost of construction and operation of one kilometer of the road network, UAH; δ – density of the transport network, 1/km;

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F_r – residential area of the city, km^2; T^{ST} – summary time of medium-range haul cycle, h.

From the above, it is clear that the road network affects the density and summary haul cycle time of the medium range.

There is no doubt that the combined time of a medium-range haul cycle depends on the length of the medium-range haul cycle, which in turn is determined by the features of the road network pattern.

Under these conditions, it is a fair assertion that the optimal aggregate haul cycle time of the medium range is the minimum time. Minimization of the combined time of medium-range haul cycle can be ensured by increasing the haul cycle speed or by reducing its range.

The haul cycle speed is a quantitative reflection of the complex interaction of a set of factors, among which are the technical capabilities of the vehicle, road characteristics, the number and nature of stops and the like. Reducing the haul cycle distance is achieved by determining the shortest route option for a haul cycle. When planning variants of route schemes, modern mathematical approaches mainly use the theory of graphs.

Let's calculate the matrix of shortest distances between the regional centers of Ukraine. For this let's use ArcGIS software (USA) and models of automobile and railway networks in Ukraine. The next step is calculation of the geographical distances between the regional centers of Ukraine. The results of the calculations are summarized in Table 1.

Table 1

Matrix of geographical and actual distances between the nodes of the transport network of Ukraine

No. of transport node	Distance between transport nodes in the existing network, km						
	1	2	3	---	23	24	25
1	0.00	615.58	902.68	---	354.36	396.61	285.03
2	484	0.00	287.09	---	367.02	604.27	884.40
3	693	209	0.00	---	654.11	852.00	1171.50
4	115	500	705	---	359.11	290.92	366.35
5	519	77	193	---	442.41	693.60	959.79
---	---	---	---	---	---	---	---
21	419	272	419	---	388.88	721.19	809.73
22	111	595	804	---	496.94	476.51	180.75
23	258	241	446	---	0.00	363.98	636.07
24	318	429	603	---	236	0.00	657.26
25	217	673	879	---	467	522	0.00
No. of transport node	1	2	3	---	23	24	25
	Geographical distance between transport nodes of the existing network, km						

Based on the obtained results, it is possible to calculate the coefficient of straightness of the investigated road network:

$$k_{SN} = 1 - (L_{r\min} / L_{geo}), \qquad (2)$$

where k_{SN} – the coefficient of straightness of the road network; $L_{r\ \min}$ – the minimum length of the route between nodes of the network, km; L_{geo} – the geographical distance between nodes, km.

The calculations of straightness coefficient of the road network for each of the nodes of the investigated network are made. The results are summarized in Table 2.

Obtained values of the straightness coefficient of the road network for each pair of nodes of the investigated system provide information on the pattern quality of the network under consideration.

Table 2

Estimated values of the straightness coefficient of the road network k_{SN} for each pair of nodes of the investigated system

No. of transport node	The value of straightness coefficient of the road network k_{SN}													
	1	2	3	4	5	6	7	---	20	21	22	23	24	25
1	0.00	0.27	0.30	0.40	0.33	0.37	0.34	---	0.34	0.33	0.28	0.37	0.25	0.31
2	–	0.00	0.37	0.36	0.26	0.30	0.37	---	0.40	0.27	0.27	0.52	0.41	0.31
3	–	–	0.00	0.34	0.31	0.32	0.36	---	0.41	0.33	0.30	0.47	0.41	0.33
4	–	–	–	0.00	0.40	0.24	0.11	---	0.23	0.33	0.20	0.39	0.29	0.23
5	–	–	–	–	0.00	0.35	0.41	---	0.31	0.36	0.32	0.50	0.39	0.39
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
22	–	–	–	–	–	–	–	---	–	–	0.00	0.36	0.25	0.23
23	–	–	–	–	–	–	–	---	–	–	–	0.00	0.54	0.36
24	–	–	–	–	–	–	–	---	–	–	–	–	0.00	0.26
25	–	–	–	–	–	–	–	---	–	–	–	–	–	0.00

The actual quality values of the road network pattern determine the priority directions of its development. With the help of the dependence (1), the calculation of total public transportation costs is determined. The cost of one hour of transport time is a component of this dependence and is a derivative, including the mileage of vehicles. This makes it possible to determine the potential public transportation costs for individual transport nodes of the road network.

6. Research results

From the performed calculations it is possible to calculate the average value of the straightness coefficient of the road network k_{SN} for each of the nodes. The histogram shown in Fig. 1, in which the cities – regional centers of Ukraine correspond to the transport nodes of the investigated network.

From Fig. 1, it can be concluded that transportation to Kherson, Odesa or Simferopol is carried out on routes that are on average 44 %, 46 % and 64 % more than possible if there is an appropriate road network. Optimal pattern of the road network has in relation to Kyiv, Zhytomyr and Kharkiv. In this case, the straightness coefficient of the road network k_{SN} is 0.24; 0.29 and 0.29, respectively.

Similarly, the values of the straightness coefficient of the road network k_{SN} for Kharkiv are compared with other regional centers of the country. The diagram given in Fig. 2 is built based on the obtained results.

From Fig. 2, it can be concluded that in the existing road network of Ukraine, it is possible to build such routes between the cities of Kharkiv and Kropyvnytskyi, which is 18 % longer than the geographical distance between these nodes of the network. At the same time, the investigated road network suggests the organization of communication between the cities of Kharkiv and Cherkasy with the straightness coefficient ratio of the road network – 0.6.

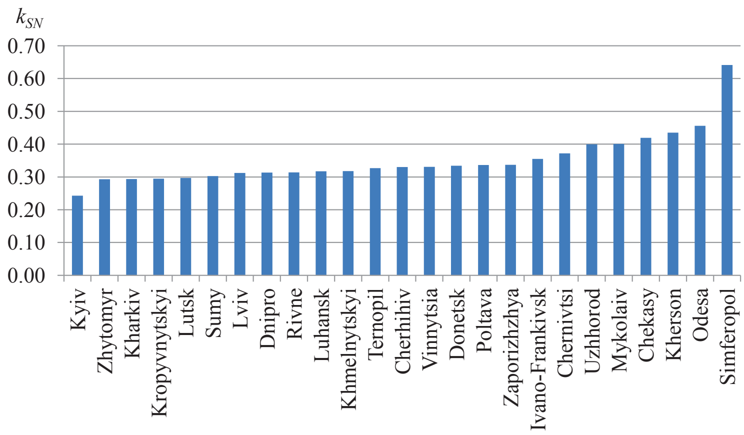

Fig. 1. The value of the average straightness coefficient of the road network in Ukraine

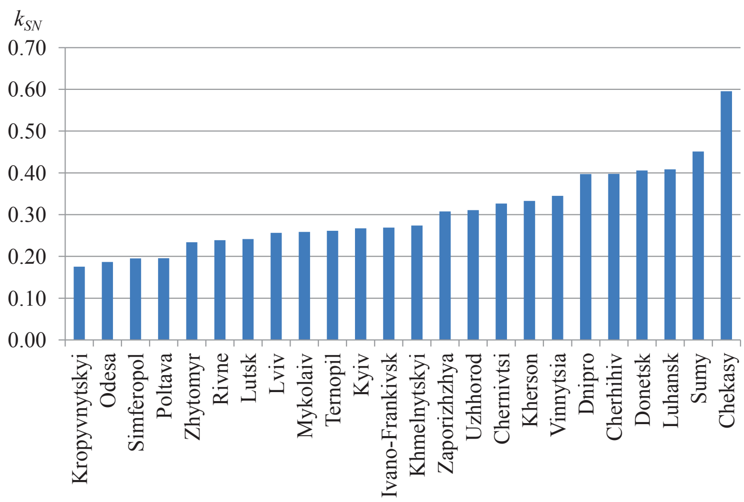

Fig. 2. The value of the straightness coefficient of the road network k_{SN} for Kharkiv

7. SWOT analysis of research results

Strengths. Among the strengths of this research can be attributed the possibility of applying a certain straightness coefficient of the road network in assessing the options for locating production sites. This will ensure the possibility of minimizing the transport component in the final cost of production that will have positive social and economic consequences. New information is obtained for non-investigated characteristics of the road network in Ukraine.

Weaknesses. The weaknesses of the conducted research and the obtained results can be attributed to the failure to take into account the fact of the railway network existing in Ukraine. However, it should be noted that the aim of the work is to study the impact of the road network pattern on the main indicators of the transport process functioning. Taking into account the fact of getting more distribution of automobile than railway tracks, it can be considered that the aim of the work is fulfilled. Also, in the course of the research, shortest variants of combinations of transport nodes are considered, realized taking into account the possibility of driving on all roads. This leads to the establishment of short routes, which are forever the fastest. It should be determined that the implementation of the obtained research results does not bear additional financial burden on transport enterprises or passengers.

Opportunities. Accurately calculated value of the straightness coefficient of the road network allows to ensure the planning of the development of transport infrastructure objects to meet the needs of the country's population in meeting the transportation needs within the investigated system. At the same time, there is an opportunity to improve the quality of the financial flows of production through the optimization of resource allocation.

Threats. There are difficulties in applying the research results. This is due to the optimization of the selected model of the road network by introducing additional arcs into it. It is proposed to realize the needs for moving between nodes of the network by the shortest possible options, which can lead to the use of arcs of the network with a relatively slow connection speed. This can lead to an increase in the total haul cycle time.

8. Conclusions

1. To determine the efficiency indicators of road networks, the impact of the development of the road network on social and economic indicators, it is suggested to use methods of system analysis. The actual state of development of road networks is determined with geostationary means of geoinformation systems on the example of Ukraine. When planning variants of route schemes, modern mathematical approaches mainly use graph theory. The matrix of shortest distances between the regional centers of Ukraine is calculated. As a result of the research it is shown that transportation to Kherson, Odesa or Simferopol is carried out on routes that are on average 44 %, 46 % and 64 % more than possible if there is an appropriate road network.

2. It is determined that the quality of the transport network pattern can be described by the straightness coefficient. The definition of the straightness coefficient of the road network is given. Calculations of the values have established that in the considered network this coefficient takes values from 0.24 to 0.64. Investigated road network offers the organization of communication between the cities of Kharkiv and Cherkasy with the straightness coefficient of the road network – 0.6.

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ВЛИЯНИЕ ОСОБЕННОСТЕЙ РИСУНКА ТРАНСПОРТНОЙ СЕТИ НА ДЛИНУ ЕЗДКИ МЕЖДУ ЕЕ УЗЛАМИ НА ПРИМЕРЕ ТРАНСПОРТНОЙ СЕТИ УКРАИНЫ

Исследованы современные подходы к определению влияния параметров и рисунка дорожной сети на эффективность функционирования транспорта. Установлено, что параметры межобластных перевозок зависят от характеристик дуг и общего рисунка дорожной сети. Определено понятие коэффициента прямолинейности дорожной сети и рассчитаны его значения для исследованной сети.

Ключевые слова: дорожная сеть, эффективность транспортного процесса, коэффициент прямолинейности сети.

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