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METHODOLOGY FOR ASSESSING THE PROSPECTS FOR DEVELOPING THE BORDER CROSSING POINT NETWORK OF UKRAINE

Introduction. *The dynamic development of Ukraine's foreign economic relations with EU Member States, as well as the availability of powerful transit capacity, are the preconditions for growing passenger and freight traffic across the state border of Ukraine. These trends increase the load on the existing border checkpoints, most of which currently require upgrade and reconstruction. Zakarpatska Oblast is a strategically important logistics, investment, and tourist gateway to the EU for Ukraine. Nineteen border crossing points (BCPs) have been operating at its territory. The opening of 18 more BCPs has been declared in the regulatory documents of various levels and types. Meanwhile, it is rather expensive and impracticable to open all the mentioned BCPs at the same time.*

Problem Statement. *The existing network of border checkpoints is characterized by outdated infrastructure, long time of crossing the border, unequal distribution of border checkpoints and high load level, etc. The opening of new BCPs will redistribute the passenger and freight traffic and balance the inflows and outflows.*

Purpose. *The research aims at developing the methodology to assess the priority of opening the BCPs at the state border in Zakarpatska Oblast and to calculate on this basis the integral index of promising border checkpoints.*

Materials and Methods. *To develop the methodology, the authors have used the systemic approach that takes into account the complexity of the research object; the horizontal and vertical links; poor predictability of the object; functional designation of border checkpoints, etc. The promising border checkpoints have been ranked based on the index method.*

Results. *The methodology for assessing the priority of opening the border checkpoints has been developed. The research deliverables are the rankings of promising border checkpoints formed based on the calculation of the integral index.*

Conclusions. *The research has outlined the prospects for applying the methodology to assess the priority of opening the border checkpoints and for developing the BCP network at the state border in Zakarpatska Oblast.*

Keywords: border crossing points (checkpoints), border regions, Ukraine-EU cross-border space, development of border infrastructure, methodology to assess the prospects for opening border crossing points (checkpoints), and Zakarpatska Oblast.

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The modern world economy has been developing in the conditions of global turbulence, high mobility of capital and competition for investment, the prevalence of network forms of industrial cooperation and logistics, and so on. Thus, the strengthening of international economic integration implies the need to find new incentives and drivers for economic growth of Ukraine as one of the largest European country in terms of territory and population and at the same time, one of the least advanced economies in the region. The advantages of the geopolitical position and the extensive network of all modes of transport may be a powerful catalyst for the development of the country and its regions. Ukraine is situated at the crossroads of world trade routes of Europe and Asia ("New Silk Road"), India and Scandinavia, etc. The integration of the national network of international transport corridors into the European and international transport networks and the development of logistics infrastructure contribute to the efficient realization of transit and trade capacity and the transformation of Ukraine into a global transit hub.

At the same time, according to the recent studies, Ukraine uses as little as 25—30% of its transit capacity [1]. Today, the situation is characterized with a low level of interoperability of the transport system of Ukraine with the Trans-European Transport Network (TEN-T) and a general technological lag behind TEN-T. The low level of the use of transit capacity is one of the constraining factors in developing international trade, attracting foreign direct investment, and integrating into regional and global value chains. It should be noted that the country's involvement in the projects focused on the development of TEN-T allows Ukraine to partially cover the costs of improving the transport and operational quality of national roads at the expense of the European Bank for Reconstruction and Development.

The transport network of Zakarpatska Oblast is a component of the EU's strategic transport and logistics corridors. In November 2017, Ukraine and the EU signed the document on the extension of indicative maps of the European transport network TEN-T to Ukraine. Two of the nine transport corridors are directly adjacent to the border with Ukraine, both pass near border crossing points (BCP) on the border of Zakarpatska Oblast: the railway BCPs Chop (Strazh) and Chop (Druzhba), the road BCPs Uzhgorod and Luzhanka. BCPs at Pavlove, Chop ((road and railway (2)), and Dyakove (road and railway), etc. are the elements of Europe-Caucasus-Asia (TRACEKA) corridor.

In recent years, Ukraine's export-import operations have been characterized by high growth rates, primarily due to the dynamic development of foreign economic activity with EU member states. The growing passenger and freight traffic across the state border of Ukraine has increased the load on the existing BCPs, most of which currently need modernization and reconstruction. Given the limited capacity and high growth dynamics of crossings, the potential for the development of some BCPs has been almost exhausted. This necessitates the search for options to increase the capacity of the BCP network. Along with the upgrade of the existing BCPs, the arrangement of service areas, and the redistribution of traffic flows through other BCPs, opportunities for opening new BCPs should be considered in order not only to reduce the burden on the existing, but also to facilitate business and investment activities in the EU-Ukraine cross-border area.

The purpose of this research is to develop a methodology for assessing the priority of opening BCPs on the state border and calculating, on its basis, an integral index of promising BCPs in Zakarpatska Oblast.

While determining the priority of opening BCPs on the state border, the decision makers use a systematic approach that takes into account the following factors: the complexity of the object; the horizontal and vertical relationships; a low predictability of the object (passenger and freight traffic forecasts); the functional purpose of BCPs, etc.

An efficient mathematical and economic tool for the study of traffic flows on road networks is

the apparatus of the theory of transport flows, queuing, and so on. Methods for solving the problem of maximum transport flows (transport network capacity) are based on the theorem of Ford-Fulkerson [2]. The relationship between the intensity of flows, their distribution in the road network, the length of queues, and the intensity of servicing the transport facilities at BCPs on the state border of Ukraine are studied by the theory of queues [3].

Most of the studies of Ukrainian researchers deal with the issues of the spatial development of border areas, the development of border infrastructure [4—5], the integration of the national transport network into international transport corridors [6—7], and the directions for developing Ukraine's transit capacity [8—9]. At the same time, the issues of socio-economic preconditions for opening new BCPs remain out of consideration, and there have been no systematic studies of the BCP network development so far.

The liberalization of foreign economic activity of Ukrainian enterprises and the deepening of the integration of Ukraine's economy into the global economic system are the prerequisites for the further increase in the passenger and freight traffic across the state border of Ukraine. Up to 2020, there have been reported positive dynamics of the growth in crossings at BCPs for almost all modes and directions. In 2000—2019, the number of crossings increased by 67%, for pedestrians; by 81%, for cars; by 22%, for buses; and more than twice, for trucks. The high dynamics of border crossings in the category of trucks is explained by the intensification of export-import operations and an increase in the transit traffic. In particular, in 2017—2018, the transit traffic accounted for about 60% of the total cargo traffic through Chop (Tysa) — Zahony BCP and 48% of the total cargo traffic through the Dyakove — Halmeu BCP [13].

At the same time, the number of border crossings by railway passenger trains decreased three times. The decrease in the number of crossings by cargo trains (by 11%) is partly explained by the military conflict in the south-eastern part of Ukraine and the commodity structure of Ukraine's export-import operations. The share of border crossings by airplane passengers increased significantly, from 2.3 to 20 million people, in 2000—2019.

In 2000—2019, the share of crossings by road transport through the border with the EU member states increased from 50% to 57%, and that by railway transport grew from 37% to 40%. At the same time, the share of Ukraine's common border with four EU member states in the total length of Ukraine's state border is 25%. The Ukraine—Poland, Ukraine—Slovakia, and Ukraine—Hungary sections of the state border of Ukraine are characterized by a high intensity of railway and road transport. The calculations of the load index (the persons and vehicles crossing the border line per 1 km of the state border of Ukraine) in 2019 have shown that the highest load from railway passenger and road passenger transport is reported for the Ukraine—Hungary border; that from railway freight transport falls on the Ukraine—Slovakia section. The load from freight transport is more balanced: 1478 trucks through the Ukraine—Poland section, 1346 ones through the Ukraine—Hungary section, and 972 trucks through the Ukraine—Slovakia section.

Increasing the load on BCPs necessitates increasing the capacity of the BCP network in these parts of the border. In 2020, the share of foreign trade operations with the EU in the total foreign trade operations of Ukraine averages 40%; 12.33% of the revenues from export of goods and 13.56% of those from import of goods belong to the neighboring countries (Poland, Slovakia, Hungary, and Romania). The share of EU member states in the total inflow of foreign direct investment in Ukraine, which accounts for 78.9%, at the end of 2019, is also very important.

The tendency to increase the share of transportation of goods and passengers by road and the positive dynamics of such transportation have raised the issue of increasing the capacity of the existing road BCP network across the state border of Ukraine, including by opening new ones.

At the legislative level, these issues are guided by the Regulation for Border Crossing Points and Checkpoints (approved by the Resolution of the Cabinet of Ministers of Ukraine on August 18, 2010, No.751). According to the document, BCPs are classified by categories, type of services, mode of transport, mode of operation, and time of operation. Border and customs control of persons, vehicles, and goods crossing the border is carried out at checkpoints. In the cases specified by law, phytosanitary, veterinary and sanitary control is carried out as well.

The main functions of the border are contact and filtering ones. These functions require a developed network of BCPs that facilitates accessible, fast, comfortable, and safe border crossing by people goods, and vehicles. According to modern requirements for BCPs, they shall ensure

Table 1. **Integral Index Components**

System characteristics of the operation of existing road BCPs	National level	Combined load coefficient		
	Regional level	Load per border section	Design load coefficient	
			Possibility to increase the capacity	
		Incoming and outgoing traffic	Traffic intensity non-uniformity coefficient	
			Average waiting time	
		Traffic concentration	Share in the overall traffic distribution	
			Traffic dynamics	
Basic parameters of promising BCPs		Density of checkpoints	Distance between neighboring checkpoints	
		Integration into transport network	Access road	
			Connection road	
			Compatibility with international highways	
		Regulative framework	International agreements	
			Bilateral agreements	Bilateral agreements at the level of central governments
				Joint cross-border strategies
				Bilateral agreements at the level of local governments
			Regulations of the central government	Strategic documents
				Program documents
			Regulations of regional government	Strategic documents
				Program documents
				Urban planning documents
				Other documents
			Regulations of local government	Strategic documents
				Program documents
				Urban planning documents
				Land allocation documents
Expert assessment of prospects for passenger and freight traffic	Proximity to major transport hubs Proximity to major industrial hubs Proximity to industrial parks, logistics centers, economic development zones, etc. Concentration of tourist facilities, location on the territory of biosphere reserves, sanctuaries, etc. Proximity to airports Close cross-border links at the local level			

effective processing of data on freight and passenger traffic, have the means to detect breaches, and to create a positive image of the state [11]. From an economic point of view, the most important prerequisite for opening a BCP is prospects for ensuring smooth uninterrupted traffic through it. Therefore, given the basic functions of BCPs, modern requirements for their opening and arrangement and prospects for keeping the positive dynamics of passenger and freight traffic, a method to assess the priority of opening BCPs across the state border of Ukraine has been proposed.

We consider the development of BCP network across the state border a complex system, with checkpoints, transport networks, and traffic flows as its elements. Each of them has a structural, informational, and functional model.

The information model of the BCP network includes the following elements and their characteristics:

- The checkpoints (density; regulatory and legal support for their opening; proximity to major transport hubs, industrial hubs, industrial parks, logistics centers, economic development zones, airports, etc.; concentration of tourist facilities, location in biosphere reserves, sanctuaries; the presence of close cross-border communications at the local level);
- The transport networks (availability of access roads, road networks; status of public roads of national importance; compatibility with international highways);
- The traffic flows (vehicle traffic across the state border of Ukraine by border sections, by categories and in terms of each checkpoint; the share of vehicles crossing the state border of Ukraine by border sections and in terms of each checkpoint; design capacity of checkpoints; load per checkpoint, the traffic intensity non-uniformity coefficient, the average waiting time at the border, established time frameworks for all types of control, the share of checkpoints in the overall distribution of passengers and freight traffic, the traffic dynamics).

To determine the priority of opening checkpoints across the state border, a methodology for assessing such priority based on the calculation of the integral index of promising checkpoints has been developed. The methodology is based on a systematic approach, given the complexity of the object of study; horizontal and vertical connections; low predictability of the object (passenger and freight traffic forecasts); function of checkpoints, etc. The rating of promising checkpoints is formed on the basis of the calculation of the integral index. The components of the integral index are shown in Table 1.

Given the complexity of the system connections of the object of study and the multifactorial impact on the distribution of passenger and freight traffic through checkpoints at the state border, the authors have proposed to use the integral index of promising checkpoints, which takes into consideration the horizontal and vertical traffic distribution parameters, the BCP function (commercial, touristic or local [1], etc.) and the prospects for passenger and freight traffic estimated based on the location of BCP in relation to transport and industrial hubs, industrial parks, logistics centers, airports, etc.

The method for calculating the integral index I^i_{int} is as follows:

$$I^i_{int} = \{\langle F^j_{NL}\rangle, \langle F^j_{RL}\rangle, \langle F^i_{BCP}\rangle, \langle EE^i_{BCP}\rangle\}, \qquad (1)$$

where F^j_{NL} is the combined vehicle load coefficient per border section at the national level by all j border sections ($j, j - \overline{1.4}$) per 1 km border. It is calculated given the established time frameworks for passing all stages (types) of control [12]. The weight [2] (w_{Fnl}) of the mentioned combined coefficient is 0.2;

F^j_{RL} is the combined load coefficient at the regional level, which includes the load parameters

[1] Local checkpoints are intended for crossing the state border of Ukraine by citizens of Ukraine and neighboring countries, who live in border areas (regions), and by their vehicles, unless otherwise provided by international agreements of Ukraine.

[2] The weights are determined by the expert method.

for a border section (design load coefficient and possibility for increase in capacity), the incoming and outgoing traffic (traffic intensity non-uniformity coefficient and averaged waiting time), the traffic concentration (the share in the total traffic distribution and traffic dynamics). The weight (w_{Frl}) of the mentioned combined coefficient is 0.3;

F^i_{BCP} is the combined weight of each i-th new BCP ($i, i - \overline{1.18}$), which takes into consideration the density of BCPs, the integration into transport network and the regulative framework for opening BCPs. The weight (w_{Fbcp}) of the mentioned combined coefficient is 0.3;

EE^i_{BCP} is expert evaluation of expected passenger and cargo traffic. The weight (w_{EEbcp}) of the expert evaluation is 0.2.

1. Combined vehicle load coefficient per border section at the national level $\boldsymbol{F_{NL}}$ is calculated separately for each border section (Ukraine—Poland, Ukraine—Slovakia, Ukraine—Hungary, etc.) according to formula (2) (for promising BCPs, the type of traffic, freight and passenger):

$$F^j_{NL} = \frac{\sum^n_{i=1} N^j_{c,i} \times t^j_{c,i} + \sum^n_{i=1} N^j_{b,i} \times t^j_{b,i} + \sum^n_{i=1} N^j_{tr,i} \times t^j_{tr,i}}{L^j_b}, \quad (2)$$

where N^j_c is the number of cars that crossed the state border of Ukraine for four years (n = 4, 2015—2018), pcs;

t^j_c is the average time for passing all types of control at checkpoints across the state border of Ukraine (8 min per one car with two passengers), min;

N^j_b is the number of buses that crossed the state border of Ukraine for four years (n = 4, 2015—2018), pcs;

t^j_b is the average time for passing all types of control at checkpoints across the state border of Ukraine (100 min per one bus with 50 passengers), min;

N^j_{tr} is the number of trucks that crossed the state border of Ukraine for four years (n = 4, 2015—2018), pcs.;

t^j_{tr} is the average time for passing all types of control at checkpoints across the state border of Ukraine (15 min per one truck), min;

L^j_b is the length of the border section, km.

For the BCPs to be crossed only by pedestrians and cars, F^j_{NL} is calculated by formula (3):

$$F^j_{NL} = \frac{\sum^n_{i=1} N^j_c \times t^j_c}{L^j_b}. \quad (3)$$

For the BCPs to be crossed by cars, busses, and pedestrians, F^j_{NL} is calculated by formula (4):

$$F^j_{NL} = \frac{\sum^n_{i=1} N^j_c \times t^j_c + \sum^n_{i=1} N^j_b \times t^j_b}{L^j_b}. \quad (4)$$

The results of calculations by formulas (2)—(4) have shown that the greatest load is reported for the Ukraine—Hungary section of the border, so the data have been normed with respect to the data for this section of the border.

2. Combined load coefficient at the regional level $\boldsymbol{F_{RL}}$ is calculated separately for each border section (Ukraine—Poland, Ukraine—Slovakia, Ukraine—Hungary, etc.) according to formula (5):

$$F^j_{RL} = Lo^j_b \times w^j_{Lo} + Tr^j \times w^j_{Tr} + Co^j \times w^j_{co}, \quad (5)$$

where Lo^j_b is load index for a particular border section with weight w^j_{Lo} = 0.3. This index (design load factor) is calculated according to formula (6) as the ratio of the actual and design data on capacity at a particular section of the border by category (cars, buses, trucks):

$$Lo^j_b = \frac{\sum^4_{n=1} \sum^z_{i=1} YQ^j_{z,n} / 365}{\sum^z_{i=1} CQ^j_z} / 4, \quad (6)$$

where $YQ^j_{z,n}$ is the number of crossings of the state border during one year (i for checkpoint, z is the number of checkpoints on a particular section of the border, n is the number of years);

CQ^j_z is design capacity of each BCP in terms of each category of transport, pcs.;

Tr^j is incoming and outgoing traffic on a particular border section with weight w^j_{Tr} = 0.3. This index is calculated as sum of traffic intensity non-uniformity coefficients balanced in equal proportions Int (by formula (7)) :

$$Int = \sum_{i=1}^{N} \left(\frac{(Q_{max(i)} - Q_{ave(i)})}{(Q_{max(i)} - Q_{min(i)})} \times 100 \times s_i \right), \quad (7)$$

where $Q_{max(i)}$ is the maximum number of crossings per day by vehicles of a particular category at checkpoint *i* in 2018;

$Q_{min(i)}$ is the minimum number of crossings per day by vehicles of a particular category at checkpoint *i* in 2018;

$Q_{ave(i)}$ is the average number of crossings per year by vehicles of a particular category at checkpoint *i*; s_i is the share of a particular BCP in the total amount of crossings by a particular category;

and average waiting time at BCP T_{ave} (min).

Co^j is traffic concentration coefficient with weight $w^j_{co} = 0.4$. It is calculated by formula (8):

$$Co^j = Sh^j_{fl} \times D^j_{fl}, \quad (8)$$

where Sh^j_{fl} is the share of a particular section of the border in the total distribution of flows of a particular category across the state border in Zakarpatska Oblast, %;

D^j_{fl} is the index of change in a particular category traffic at a particular border section as compared with the previous year (traffic flow index), %.

3. Combined weight of BCP F_{BCP} is calculated separately for each promising BCP (*i*), by formula (9):

$$F^i_{BCP} = D^i_{st} \times w^i_{D} + TN^i \times w^i_{TN} + RS^i \times w^i_{RS}, \quad (9)$$

where D^i_{st} is the BCP density index with weight $w^i_{D\,st} = 0.2$; TN^i is the index of integration into transport network, with weight $w^i_{TN} = 0.4$; RS^i is the index of regulative framework for opening of new BCP, with weight $w^i_{RS} = 0{,}4$.

To calculate the combined weight of BCP F^i_{BCP} and the expert evaluation of prospects for sufficient passenger and freight load on BCP EE^i_{BCP}, we use the score system within the range [0.1][3].

To estimate D^i_{st} we take into consideration the distance between neighboring operating BCP for a particular category of crossings between which a new BCP is expected to be built. If the distance is larger than 50 km, this new BCP scores one point, otherwise it gets 0.

The index of BCP integration into transport network TN^i takes into consideration the availability of an access road (on both sides of the border line — 1 point, on one side only — 0.5 points, none — 0); the availability of connection road (on both sides — 1 point, on one side only — 0.5 points, none — 0), connectivity with international highways and motorways (directly adjacent — 1 point, located at a distance of 20 km — 0.5 points, more than 20 km — 0) (on both sides of the border). The weights are 0.2, 0.3, and 0.5, respectively.

The evaluation of regulatory framework takes into account the existence of *international agreements*[4]*; bilateral documents* (bilateral documents at the level of central government, joint cross-border strategies, bilateral agreements at the level of local government); *legal acts and regulations of central government* (strategic documents, program documents); *regulations at the regional level* (strategic documents, program documents, urban planning documentation, allocation of funds); *regulations at the local level* (strategic documents, program documents, urban planning documentation, land allocation). Depending on the mention of a particular BCP in the legislation of both countries, one country or the absence of mention in the documents of any of the countries, "1", "0.5" or "0" points are assigned respectively. The weights are 0.5, 0.2, 0.15, 0.1 and 0.05, respectively.

4. Expert estimate of prospects for sufficient passenger and cargo traffic EE_{BCP} includes the following factors: the location of BCP with respect to *large transport and industrial hubs, industrial parks, logistics centers, economic development areas, tourist sites, biosphere reserves, reserves, airports and the factor of close cross-border links at the local level.* The evaluation process takes into consideration the distance between a promising BCP

[3] The characteristics that cannot be calculated are estimated with the use of a scoring.

[4] The mandatory condition for the Cabinet of Ministers of Ukraine to make a decision on the opening of checkpoints for road, railway, pedestrian, ferry (in some cases) and river (in some cases) connections is signing an international agreement of Ukraine with a neighboring country pursuant to CMU Regulations for border crossings and checkpoints of August 18, 2010 No. 751).

and such facilities. If there are large transport and industrial hubs, industrial parks, etc., within a radius of 100 km, tourist sites, biosphere reserves, airports, etc. within 60 km, their effect is taken into account in the estimation. If a promising BCP is to be located within the range of the effect of the factor on both sides of the border, the BCP scores 1 point, if it is on one side, the BCP is assigned with 0.5 points, otherwise 0 points.

The integral index is calculated based on the example of promising checkpoints in Zakarpatska Oblast as a strategically important logistic, investment, and tourism gate from Ukraine to the EU. The region borders with four EU member states (Poland, Slovakia, Hungary, and Romania), with the borderline length reaching about 470 km.

Zakarpatska Oblast is the leader among other regions of Ukraine in terms of the shares of exports and imports in regional GDP. The region completely focuses its foreign economic activity on the EU market whose share in region's export and import accounts for more than 90% and 60%, respectively. The autonomous trade preferences regime: the unilateral (by the EU) abolition of import duties, which is applicable to 94.7% of total industrial goods and 83.4% of agricultural goods and food products imported by the EU from our country (valid until January 1, 2016) and the creation of the DCFTA (Deep and Comprehensive Free Trade Area) have allowed Zakarpatska Oblast to increase the exports of goods and services by 28% and the imports by 24%, in 2015—2020.

The existing BCP network in Zakarpatska Oblast is characterized by outdated infrastructure of checkpoints, long border crossing time, uneven placement of checkpoints, high load, etc. The opening of new BCP will redistribute passenger and freight flows and balance the incoming and outgoing traffic along the entire state border.

To date, there have been 19 BCPs in Zakarpatska Oblast, three of which are temporarily closed. There are have been operating 9 road, 5 railway, and 2 pedestrian BCPs. The analysis of the distribution of passenger and freight traffic by the sections of the state border of Ukraine in Zakarpatska Oblast in 2015—2018 has shown the following trends:

- in Zakarpatska Oblast, about 65% of citizens cross the state border on the Ukraine—Hungary section;
- in 2018, the share of Ukraine—Hungary section in the total amount of border crossings by railway passengers amounted to 90%;
- the main share of freight traffic falls on Ukraine—Slovakia section of the border. In 2015—2018, it decreased slightly from 76.93% to 69.52%;
- there is reported an increase in the share of Ukraine—Hungary section in the traffic of goods across the state border of Ukraine: from 19.5%, in 2015, to 26.18%, in 2018;
- the share of road transport in the transportation of goods increased from 12.74% to 20%, in 2015—2018.
- there is reported a positive trend in the railway transportation of goods through Ukraine—Hungary border in 2015—2018. Its share in the total freight traffic carried by railway transport increased from 15.14% to 29.48%.

The regulatory documents of various levels and types (international agreements, joint cross-border strategies, strategic and program documents, urban planning documentation, etc.) have declared the need to open 18 new BCPs across the state border in Zakarpatska Oblast. It is clear that the simultaneous opening of all these BCPs is economically impractical and very expensive.

The main socio-economic factors that determine the prospects for opening these new BCPs are as follows [10]:

- there is none BCP on the common section of the state border with the neighboring country. In particular, BCP Lubnia—Wolosate, on Ukraine—Poland section of the state border of Ukraine;
- the need to unload neighboring BCPs on the relevant section of the border in certain categories. In particular, border crossing points

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Dyida—Beregdaroc on Ukraine—Hungary and Bila Tserkva—Sighetu Marmatiei on Ukraine—Romania sections of the state border of Ukraine;

- ensuring the accessibility of the state border crossing in accordance with European practice (if the distance between neighboring BCPs exceeds 50 km). In particular, border crossing point Velyka Palad—Nagyhódos on Ukraine—Hungary section of the state border of Ukraine. The neighboring operating checkpoints are Vylok—Tiszabecs and Dyakove—Halmeu;
- obtaining a tangible socio-economic effect for the territory. In particular, BCP Zabrid—Ulič promotes the development of Ukraine—Slovakia cross-border tourism market, BCP Solomonovo—Čierna on Ukraine—Slovakia section of the state border of Ukraine creates new opportunities for foreign economic activity of economic entities of Ukraine and EU member states and opens new prospects for the development of Solomonovo Industrial Park;
- facilitating border crossing by residents of border areas (concentration of ethnic Ukrainians, Hungarians in the neighboring country; settlements historically divided by the border between the two states), for example: BCP Tyachiv—Teceu Mic and Yablunivka—Remeti on Ukraine—Romania border section. In Teceu Mic and Remeti (Remeti Commune, Maramures County, Romania) over 70% of the population is ethnic Ukrainians. In Ukraine, ethnic Hungarians are concentrated in the village of Heten (the Koson united territorial amalgamation, Berehovo Rayon, Zakarpatska Oblast, BCP Heten—Tiszakerecseny on Ukraine—Hungary section).

While developing the methodology for assessing the priority of opening BCPs across the state border and making calculations based on the integral index of promising BCPs in Zakarpatska Oblast we have:

- studied the system-wide factors influencing the sources of traffic flows and their distribution at the national, regional, and local levels;
- proposed the following indicators: non-uniformity of traffic intensity, traffic flow concentration, and average waiting time;
- developed an algorithm for processing data on the average waiting time for cars and trucks at BCPs within Zakarpatska Oblast.
- collected and systematized relevant information. The average waiting time for cars and trucks has been estimated depending on daytime and weekday. The peak load hours and minimum waiting time have been determined;
- assessed the legal framework for the opening of new BCPs based on the analysis of the existing joint strategies, programs, agreements on the development of adjacent border areas (regional, district, settlements), the development of transport networks, transport links, and transport infrastructure in the context of strengthening cooperation between border areas of Ukraine in terms of individual sections of the state border in Zakarpatska Oblast; reviewed and analyzed the national and regional strategies, concepts, programs, master plans of the territories of Hungary, Slovakia, Romania, and Poland on the prospects for the development of cross-border areas and the need to open new and to upgrade the existing border crossings;
- made expert evaluation of the prospects for sufficient load of new BCPs by passengers and cargo on the basis of the analysis of socio-economic development of Ukraine—Poland, Ukraine—Slovakia, Ukraine—Hungary, and Ukraine—Romania borders (large transport and industrial hubs, industrial parks, logistics centers, airports, etc.).

The results of the calculation of the integral index are shown in Table 2.

The development of a methodology for assessing the priority of opening BCPs across the state border and the calculation of the integral index of promising BCPs in Zakarpatska Oblast have allowed us to draw the following conclusions:

- The crucial factor for assessing the feasibility of opening a BCP is the prospect for its sufficient load from passenger and freight traffic

Table 2. **Calculation of the Integral Index of the Promising BCPs across the State Border of Ukraine in Zakarpatska Oblast**

BCP	USA					Main parameters of the promising BCPs				Expert estimate of prospects for sufficient passenger and freight traffic	Integral index
	National level	Regional level				BCP density	Integration into transport networks	Regulative franework	Combined weight of BCP		
	Combined load coefficient at the national level	Load per border section	Incoming and outgoing traffic flows	Traffic concent-ration	Combined load coefficient at the regional level						
Ukraine–Poland border section											
Lubnia–Wołosate	**0.5**	0.46	0.47	0.16	**0.34**	1	0.1	0.158	**0.303**	0.15	**0.323**
Ukraine–Slovakia border section											
Zabrid–Ulič	**0.5**	0.46	0.47	0.16	**0.34**	—	0.1	0.243	**0.137**	0.325	**0.308**
Storozhnytsia–Záhor	**0.6**	0.75	0.62	0.36	**0.55**	—	0.613	0.11	**0.289**	0.725	**0.517**
Pavlove–Matovcé	**0.6**	0.75	0.62	0.36	**0.55**	—	0.275	0.015	**0.116**	0.725	**0.465**
Palad-Komarivtsi–Ruské	**0.6**	0.75	0.62	0.36	**0.55**	—	0.425	0.118	**0.217**	0.825	**0.515**
Mali Selmentsi–Veľké Slemence	**0.5**	0.46	0.47	0.16	**0.34**	—	0.475	0.14	**0.246**	0.675	**0.411**
Solomonovo–Čierna	**0.6**	0.75	0.62	0.36	**0.55**	—	0.65	0.698	**0.539**	0.725	**0.592**
Ukraine–Hungary border section											
Solovka–Tiszaszentmárton	**1**	0.6	0.73	0.67	**0.67**	—	0.4	0.085	**0.194**	0.525	**0.564**
Solovka–Eperjeske	**1**	0.6	0.73	0.67	**0.67**	—	0.65	0.108	**0.303**	0.525	**0.597**
Heten–Tiszakerecseny	**1**	0.6	0.73	0.67	**0.67**	—	0.525	0.078	**0.241**	0.5	**0.573**
Dyida–Beregdaróc	**1**	0.72	0.58	0.65	**0.65**	1	0.713	0.673	**0.754**	0.6	**0.741**
Badalovo, Barievo–Szatmárcseke, Tiszakóród	**1**	0.6	0.73	0.67	**0.67**	—	0.513	0.13	**0.257**	0.5	**0.578**
Velyka Palad—Kispalád	**1**	0.6	0.73	0.67	**0.67**	1	0.375	0.085	**0.384**	0.275	**0.571**
Velyka Palad–Nagyhódos	**1**	0.6	0.73	0.67	**0.67**	1	0.413	0.373	**0.514**	0.275	**0.61**
Ukraine–Romania border section											
Khyzha–Tarna Mare	**0.12**	0.53	0.2	0.19	**0.3**	1	—	0.53	**0.412**	0.15	**0.268**
Yablunivka–Remeti	**0.12**	0.53	0.2	0.19	**0.3**	1	0.05	0.07	**0.246**	0.25	**0.238**
Tyachiv–Teceu Mic	**0.12**	0.53	0.2	0.19	**0.3**	1	0.1	0.015	**0.246**	0.25	**0.238**
Bila Tserkva–Sighetu Marmatiei	**0.13**	0.71	0.49	0.12	**0.41**	1	0.4	0.208	**0.443**	0.25	**0.332**

flows, which directly correlates with the level of development of the road network;

- The priority of opening BCPs should be determined based primarily on the specific section of the border and the level of congestion by category of border crossings. The priority BCPs are: Lubmia—Wołosate, on Ukraine—Poland border; Solomonovo—Čierna, on Ukraine—Slovakia border section; Dyida—Beregdaróc and Velyka Palad—Nagyhódos, on Ukraine—Hungary border; and Bila Tserkva—Sighetu Marmatiei on Ukraine—Romania section of the border;
- The restraining factors shall be taken into account for making decision on the opening of new BCPs. In particular, the proximity to settlements and the impossibility of constructing bypass roads (Storozhnytsia—Záhor, Mali Selmentsi—Veľké Slemence), the complexity of engineering solutions in terms of the design of ferry crossings given the seasonal changes in water level in the Tisza River (Solovka—Tiszaszentmárton, Badalovo—Szatmárcseke), stiffening requirements for the construction of road BCPs that operate on the territory of biosphere reserves and reserves (Lubnia—Wołosate, Zabrid—Ulič), the necessity of constructing reclamation canals passing through the territory of BCP (Solomonovo—Čierna);
- Most of the promising BCPs on Ukraine—Hungary section of the state border have received higher values of the integral index as compared with other BCPs because of higher vehicle load at both national and regional levels. About 65% of citizens cross Ukraine—Hungary section of the state border of Ukraine in Zakarpatska Oblast;
- The important factors influencing the assessment of the priority of opening BCPs are also the congestion of checkpoints by category. In particular, Ukraine—Slovakia section is congested with buses; Ukraine—Hungary is overloaded with cars; and Ukraine—Romania is abnormally full of freight transport;
- The proposed method for calculating the integral index allows determining the priorities for the opening of road checkpoints across the state border.

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ПЕРСПЕКТИВИ РОЗБУДОВИ ПУНКТІВ ПРОПУСКУ ЧЕРЕЗ ДЕРЖАВНИЙ КОРДОН УКРАЇНИ: МЕТОДИКА ОЦІНЮВАННЯ

Вступ. Динамічний розвиток зовнішньоекономічної діяльності України з країнами-членами ЄС, наявність потужного транзитного потенціалу є передумовами нарощення пасажиро- та вантажопотоків через державний кордон України. Формування зазначених трендів впливає на посилення навантаження на пункти пропуску, більшість з яких на сьогодні потребують модернізації та реконструкції. Стратегічно важливими логістичними, інвестиційними та туристичними воротами України у ЄС є Закарпатська область. На її території відкрито 19 пунктів пропуску, а у нормативних документах різного рівня та видів задекларовано необхідність відкриття ще 18 нових. Одночасне відкриття всіх зазначених пунктів пропуску є економічно недоцільним та фінансово затратним.

Проблематика. Наявна мережа пунктів пропуску характеризується застарілою інфраструктурою, тривалим часом перетину кордону, нерівномірністю розміщення, високим рівнем навантаження тощо. Відкриття нових пунктів пропуску дозволить перерозподілити пасажиро- та вантажопотоки та збалансувати вхідні й вихідні потоки.

Мета. Розробка методики оцінки пріоритетності відкриття пунктів пропуску через державний кордон та розрахунок на її основі інтегрального індексу перспективних пунктів пропуску у Закарпатській області.

Матеріали й методи. При розробці методики використано системний підхід, який враховує складність об'єкта дослідження, горизонтальні та вертикальні зв'язки, слабопрогнозованість об'єкта, функціональне призначення пунктів пропуску тощо. Рейтинг перспективних пунктів пропуску розраховано на основі індексного методу.

Результати. Здійснено розробку методики оцінки пріоритетності відкриття пунктів пропуску через державний кордон. На основі розрахунку інтегрального індексу сформовано рейтинг перспективних пунктів пропуску в Закарпатській області.

Висновки. Обґрунтовано перспективи застосування методики оцінки пріоритетності відкриття пунктів пропуску та здійснено оцінку розбудови їхньої мережі через державний кордон у Закарпатській області.

Ключові слова: пункти пропуску, прикордонні регіони, транскордонний простір Україна-ЄС, розвиток прикордонної інфраструктури, методика оцінки перспектив відкриття пунктів пропуску, Закарпатська область.