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GEOGRAPHIC STRUCTURE OF ROAD TRANSPORTATION AND LOGISTICS INFRASTRUCTURE IN THE REPUBLIC OF BELARUS

Struktura geograficzna infrastruktury transportu drogowego i logistyki w Republice Białorusi

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Abstract: Transportation, representing 6% of GDP, plays vital role in social and economic development of the Republic of Belarus. The purpose of this article is to present the geographic analysis of current spatial structure of the road transportation in Belarus in 2000-2014. The choice of transport mode for the article was influenced by several factors, such as historic development, network coverage, transformational changes in productivity, rapid increase in car ownership numbers, emergence of logistic centers and intelligent transportation systems. The article reviews the range of topics, including morphology of the major roads network, logistic centers spatial distribution and regional features of passenger and cargo productivity, discusses current transformational changes within the road transportation sector in Belarus. The key findings indicate that current changes in spatial structure of the road transportation in Belarus have uneven nature, shaped by social, economic, political and geopolitical external and internal factors and are a subject of interest for both transportation researchers and practitioners.

Key words: road transportation system, transportation accessibility and productivity, logistics geography, GIS-T models, network analysis

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1. Introduction

Belarus has an advantageous geographical location at the crossroads of major pan-European transportation corridors (West-East and North-South), namely II, IX, IXB (with the total length of 1520 km) and has significant potential for effective and adequate performance of transport and logistical systems at contemporary globalized markets. The geographical location in the center of Europe determines its transportation policy. Being a landlocked country without direct access to the sea, Belarus has to play the role of a transit corridor (UNECE, 2013).

Since 1991, during the years of the sovereignty, a number of transformational problems had challenged the transportation system of the Republic of Belarus. Due to the economic downturn and a decline of the populations' living standards, the demand and supply for road transportation services has decreased significantly, which had led to a decrease in economic performance, passenger and freight traffic volumes, as well as to the suspension of new construction projects. However, starting from the early 2000's the new tendencies of road transportation development had started in Belarus. Despite the stagnation of the road network evolution (until 2013) and decline in passenger transportation productivity (decrease in volumes of passengers carried), the growth of freight volumes and freight turnover was typical for all regions of the country. In addition, 42 new infrastructural elements – transportation and logistics centers (TLCs), were constructed, and the infrastructure of intelligent transportation systems – electronic toll collection system – had started commercial operation in Belarus.

Development of the road transportation in Belarus is defined by six main factors – historical, geographical, economic, social, environmental and regulatory. Historically the ancestor of road transportation was the first one to establish socio-economic links between the settlements of Belarus, some of which had subsequently transformed into transportation hubs. Geographically the network of highways and national roads has the largest territorial coverage in Belarus. The economic factor had influence on the change of the place and role of road transportation in the republican structure of freight and passenger traffic. Since 2000, the growth of the social and environmental impact of the increasing car ownership, related to pressure on road infrastructure, traffic congestion and environmental problems, had significantly increased. Transportation planning and regulation in Belarus plays significant role in establishing competitive and advantageous conditions for the transportation and logistics actors by introducing or scratching regulatory barriers of market entry.

Important changes in the legislative framework regarding transportation development were introduced in the 2010s. Two State Programs for Development of the Logistics Sector and for Development of the Transit Potential of Belarus were published in 2011-2015. The state authorities approved the State Program for the Development and Maintenance of Highways in the Republic of Belarus for 2015-2019 in 2015. The 2014 edition of the State Scheme of the Integrated Territorial Organization of the Republic of Belarus had formulated the guidelines for modernization of the transportation complex, ensuring safety and efficiency of its operation at the estimated (until 2020) and forecasting planning stages (until 2030). In addition, the National Strategy for Sustainable Social and Economic Development of the Republic of Belarus until 2030 was adopted in 2015, outlining directions and parameters for the development of all transportation systems in the country.

Thus, the main purpose of the article is to analyze the changes of the spatial structure of the road transportation in Belarus in 2000-2014. The specific research objectives of this paper include investigation, analysis and regional comparison of the following aspects of the road transportation development in Belarus in 2000-2014: 1) dynamics of network morphology of major roads; 2) dynamics of infrastructural development and its spatial peculiarities; 3) structural and geographic changes in freight and passenger productivity.

The article consists of six parts. First, it reviews the literature relevant to geographic analysis of road transportation systems in general and in Belarus in particular. Then the research methodology is explained and data analysis techniques are presented. Next, the findings on the research questions regarding geographic aspects of network development, productivity and logistics are presented and discussed. The final part provides the conclusion.

2. Literature review

Currently there are no fundamental works of Belarusian geographers providing the analysis of transportation systems and road transportation at regional and local spatial scales. The majority of modern transportation development programs are based on the results of economic, econometric – but not geographic – study of transportation systems. Although, the majority of publications providing economic analysis of the road transportation sector use geographic methods of data interpretation and

visualization. The main ideas of this article interpret the concepts and methodological approaches of contemporary transportation geography, presented in the works of V.N. Bugromenko, J-P. Rodrigue, E.J. Taaffe, S.A. Tarkhov, R. Tolleyand others. The analysis of the main theoretical results of the major schools of transportation geography (Anglo-Saxon, Soviet and contemporary Russian) showed that the territorial structure of transportation systems reflects the specifics of the organization of socio-economic processes of the territory (Rodrigue et al., 2013; Taaffe et al, 1996). The geographic analysis of spatial patterns of road network configuration and evolution is presented in works of Тархов (2005). The works of Rodrigue et al. (2013) and Бугроменко (2010) explained the concept of transportation accessibility in general. The geographic analysis of road transportation productivity and logistics is based on the concepts presented in the works of Rodrigue et al. (2013), Tolley (1995) and interpretation of the existing statistical data.

The existing research papers on transportation infrastructure (Жук, Миленький 2011; UNECE, 2013; Захман, 2011), productivity and transit potential (ИНП РАН, 2014; Ковалев, 2012; Сухонос, 2012) and development of the logistics sector (Антюшеня, 2016; Курочкин, 2017) in Belarus provide descent economic analysis, but the geographic component on spatial diversification is missing in the majority of those papers. Thus, the aim of this study is to fill the existing gap by analyzing the spatial structure of roads network configuration, productivity and infrastructure development. Along with this, the applied results and findings can serve as basis for road transportation development and optimization scenarios by taking into consideration specific conditions and trends of socio-economic development of the regions of Belarus.

3. Research methodology

Statistics discussed in the article is based on official data provided by the following departments: Ministry of Transport and Communications of the Republic of Belarus, National Statistical Committee of the Republic of Belarus, Main statistical offices of Brest, Viciebsk, Homiel, Hrodna, Minsk and Mahilieu regions, "Belavtodor" (the state department on roads). The data on road network was collected at "Belavtodor" department, and their official roads classification – highways, national (term regional is also used throughout the article) and local roads – is used. Additional maps analysis of roads network from the National Atlas of the Republic of Belarus and Google Maps was carried out to verify the changes in network configuration for the years 2000-2016.

Official publications of the World Bank, United Nations Economic Commission for Europe, MITSO, IPM Research Center, Kapsch TrafficCom AG and others were analyzed in order to provide the reader with better understanding of current trends in the industry.

The spatial structure of major roads (highways and regional) only was analyzed, as far as those roads serve 60-80% of freight and passenger traffic (UNECE, 2013). Along with basic geographic analysis of the road network dynamics and accessibility, the description of morphologic changes in 2000-2014, based on methodological approaches of Тархов (2005), is provided. The main idea is that in case of the network growth, its configuration complicates and formation of new layers in circuital framework occurs (Тархов, 2005). The structure of geographic analysis of network development, logistics infrastructure and productivity uses the logical scheme, which considers: a) national dynamics and structural changes, b) regional dynamics and differences and c) factors influencing performance and regional disparities of road transportation.

The analysis of logistics infrastructure in Belarus altogether with spatial analysis, considers the factors influencing the dynamics of Logistics Performance Index (LPI). The LPI is the weighted average of the country scores on the six key dimensions: 1) efficiency of the clearance process by border control agencies; 2) quality of trade and transportation related infrastructure; 3) Ease of arranging competitively priced shipments; 4) quality of logistics services; 5) ability to track and trace consignments; 6) timeliness of shipments. The score demonstrates comparative performance—the dimensions show on a scale (lowest score to highest score) from 1 to 5 relevant to the possible comparison groups—of all countries (world), region and income groups.

The maps provided in the article were made in ArcGIS software using standard geographic approach towards spatial data visualization. Measurement units of the indicators studied are provided in standard Metric System.

4. Road transportation network in Belarus

A network of predominantly radial configuration, which serves the passenger and freight traffic flows between economic centers and populated settlements, presents the road infrastructure in Belarus. The major roads, representing 18% of the total network length, support more than 60-80% of cargo and passenger traffic. Despite the 132% growth of the

whole network of paved roads in 2000-2015 (from 66.2 to 87.2 thousand km), the length of the major roads remained stable until 2013, then slightly increased at 102% when the construction started in Minsk and Brest regions. The length of highways with the status of pan-European transportation and communication corridors (II (highway M1), IX (M8) and IXB (M5 and M7)) that cross the territory of the country is 1500 km. Those highways have strategic importance, and administrative districts with their presence (51% of total amount) have a transit advantage that increases their transportation accessibility. The compact size and shape of the country explain the high level of geographical accessibility of the major roads network: the 10 km zone of accessibility covers 76.7% of the territory of the country.

activity and the importance of the existing transportation nodes. The patterns of network accessibility in Belarus are closely related to the planning axes and the settlement system, network accessibility is higher for the transportation nodes of international and regional importance (Minsk, Brest, Homiel, Hrodna, etc.).

It is worth noticing that in 2000-2013 the network of major roads in Belarus had a qualitatively new stage of morphologic development – stagnation (a special type of dynamics, when neither complexity nor simplification of configuration occurred, Тархов, 2005). The minor repair and construction works included reconstructions of individual sections of the network and the construction of detours of large cities (Mahilieu, Homiel, Bobruisk), but they did not

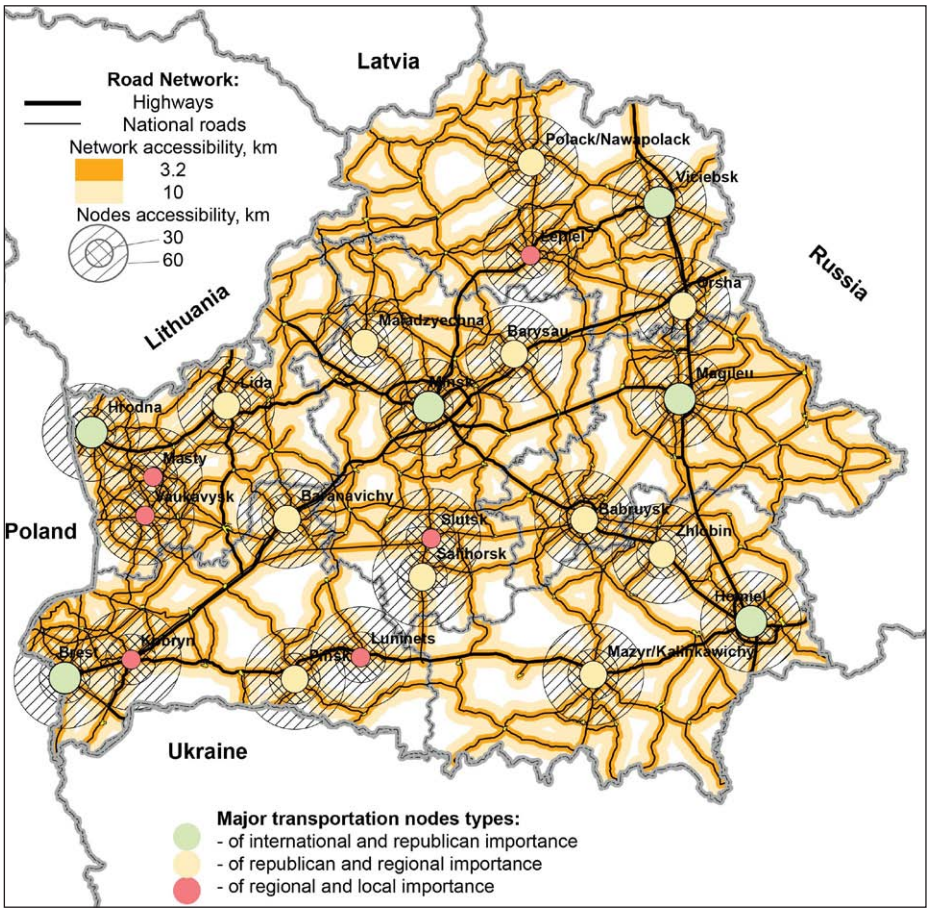


Fig. 1. Accessibility of the network of major roads and transportation nodes in Belarus

Source: own elaboration.

The areas with the lowest network accessibility are located in Viciebsk, Brest and Homiel regions. The low level of industrial activities at those areas of natural significance (Poozerye and Polesye) explains that pattern. The highest level of network accessibility correlates positively with the level of economic

affect the network morphology. The construction of new roads from 2013, namely P98 (192 km), bypassing Belovezhskaya Pushcha, and M14 (second Minsk ring road, 160 km) had paused the stagnation stage of the network evolution. The improvement of the planning structure around Minsk and between the regional

centers of Belarus and its transition from radial to the radial-ring type led to complication of the internal topological structure of the network. The new 6th topologic layer of the framework, geographically located near the Minsk-2 airport, was formed, indicating increase in transportation accessibility of this territory (fig. 2).

Belarus. In 2000-2014 the number of cars privately owned by the citizens has almost doubled (from 1386 thousand to 2830 thousand), together with the per capita numbers (from 142 to 298 per 1000 people). In 2000-2014 the maximum growth of car ownership was observed in Minsk (mainly due to the influx of economically active population to the city of Minsk

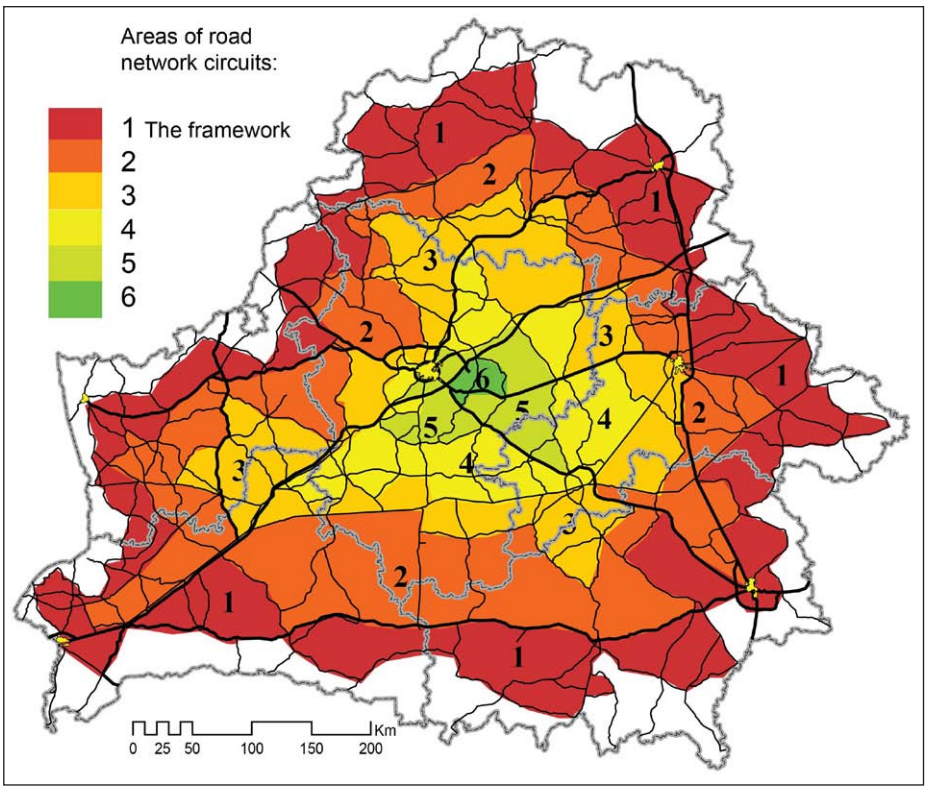


Fig. 2. The framework and circuital layers of the road network of Belarus, 2016

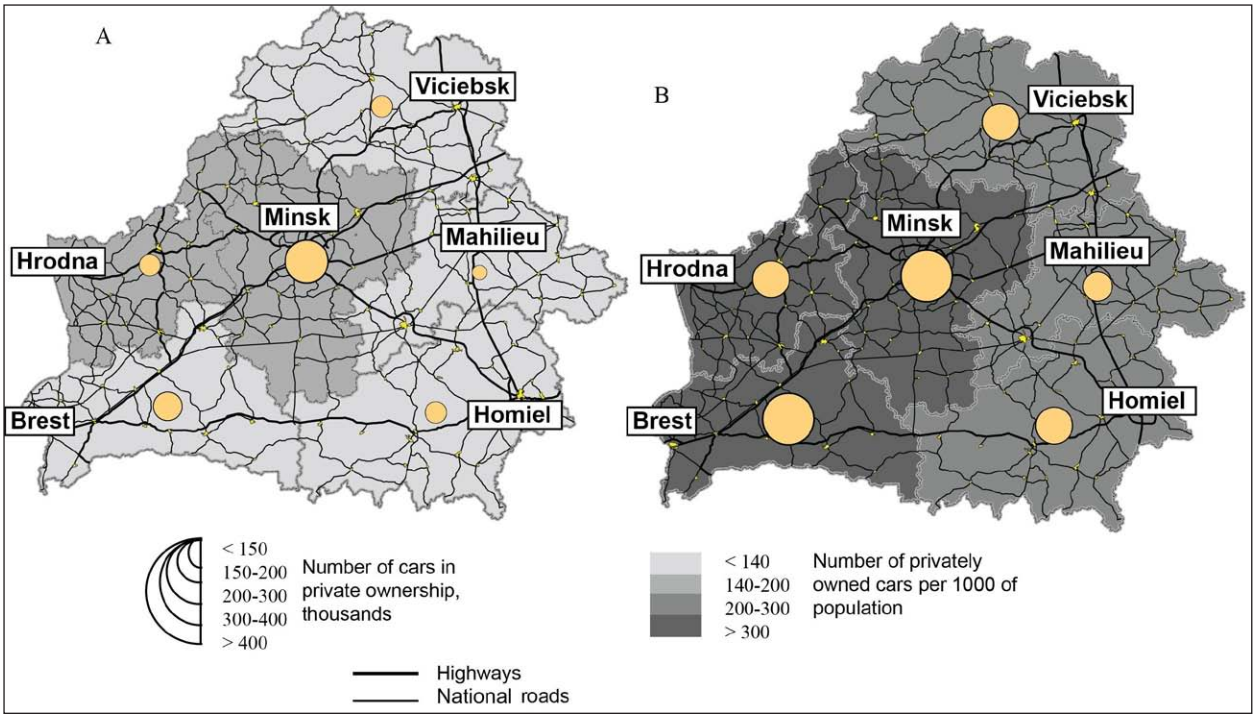
Source: own elaboration.

The territorial structure of the main roads network is defined by configuration of the existing urban settlement system, territorial organization of industrial production, and presence of transportation corridors passing through Belarus. The qualitative and quantitative structure of the network is better at areas where regional centers (and their catchment areas), regional industrial and transportation centers (the cities of Baranavichy, Polack, Babruysk, Orsha) are located. The insufficient geographic network coverage is common at naturally significant areas (Poozerye in the north, Polesye in the south) and the problematic regions of Belarus, which suffered from the Chernobyl Nuclear Power plant accident and agricultural melioration works (in the southern parts of the country).

The existing road transportation infrastructure is closely connected to the problems related to the continuous growth of private car ownership in – the capital of the country), Brest and Hrodna regions (fig. 3).

According to the calculations of the State Scheme of Complex Territorial Organization (ГСКТО, Вориводская, 2015), car ownership in Minsk and the surrounding area will increase up to 350-450 cars per 1000 people by 2030 if the current growth rates remain stable. Despite serious traffic (typical for Minsk) and environmental problems (automobiles generate the majority of the region's air pollution), the growth of car ownership can also lead to additional pressure to the existing road network. The construction of new road sections, as well as the reconstruction of main roads will increase financial costs in the road management and construction industry (Вориводская, 2015).

One of the instruments of coping with rapid motorization and of obtaining additional funding sources was the introduction of the Beltoll fare



Note: circles reflects the value of the indicator for the region

Fig. 3. Regional structure of car ownership in Belarus, 2000-2014

Source: author's elaboration based on National Statistical Committee (Национальный статистический комитет Республики Беларусь, 2016) data.

collection system in 2012. The system has been expanding from 815 to 1512 km in 2016. It was the first large-scale experience of implementation of intelligent transportation systems in Belarus, with the infrastructure being installed by the Austrian company Kapsch TrafficCom AG, acting both as developer and as operator of the toll collection system in the region. Geographically the toll road network links Minsk with the major cities (Brest, Homiel, Mahilieu) and entrance points to the country at Lithuanian, Polish and Russian borders. According to the State Program for the Development and Maintenance of Highways in Belarus for 2015-2020, the republican budget expects to receive about 5.7 trillion rubles from the toll roads. The income is supposed to contribute to the infrastructure development of Belarus and to be used for maintenance, repair and further development of the toll network (Вориводская, 2015).

5. Geography and quality of logistics sector in Belarus

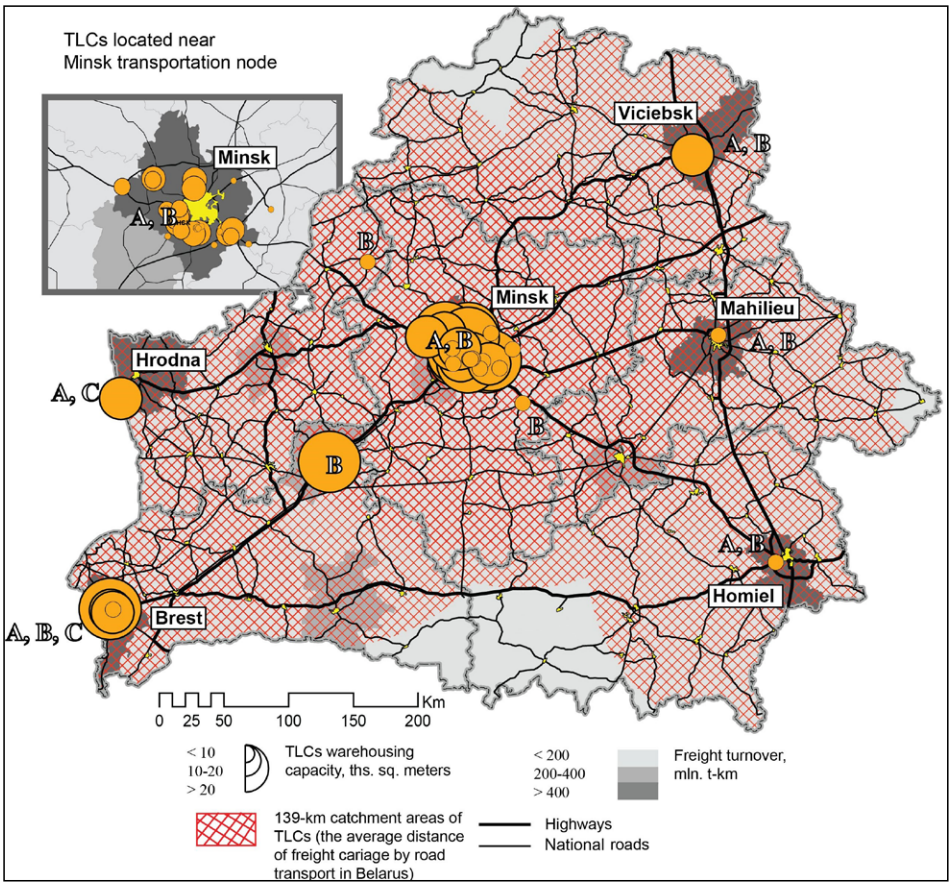
According to UNECE estimations (2013), and as shown in the previous section of this article, the Belarusian road infrastructure has good geographic coverage and is adequate for the existing freight flows. However, analysis of the logistics industry proves the hypothesis that is still under-developed and has potential for growth. The history of contemporary logistics in Belarus starts in 2008, when the State Program for the development of a logistical system of the country until 2015 was approved by the Council of Ministers. According to the Program, 39 sites in various regions and cities of Belarus (Brest, Viciebsk, Homiel, Hrodna, Mahilieu, Baranavichy, Babruysk, Barysau, Zhlobin, Mazyr, Orsha, and Pinsk, but mostly in the Minsk region – around 45%) were selected for construction of logistical centers. The main criteria and reasons for location selection were: a) availability of possibilities to increase regions' attractiveness for investors; b) opportunity to test innovative economic development model; c) ability to stimulate employment and business growth of the territory; d) presence of options to reduce transportation and logistics costs; e) proximity of major transportation networks (UNECE, 2013).

As on January 1st 2017, 42 logistic centers have been operating in Belarus (only 19 of them were constructed according to the Program goals) and 89.2% of them were located in Minsk region. The most attractive regions for the construction of logistics centers are Minsk (behind the city ring road, where the II and IX trans-European transportation corridors cross) and Brest (the border with Poland) regions. 71% of the TLCs were located in the Minsk region, and in Brest – 14% (tab. 1, fig. 4).

Tab. 1. Regional structure of TLCs by geographic types in Belarus, 2016

Region	No. of TLCs	Share (from total), %	Geographic types of TLC					
			1. TLCs near regional centers		2. TLCs near international transportation corridors		3. TLCs near borders	
			No.	% reg.	No.	% reg.	No.	%
Brest	6	14	5	83	6	100	5	83
Viciebsk	1	2	1	100	1	100	0	0
Homiel	1	2	1	100	1	100	0	0
Hrodna	2	5	1	50	0	0	1	50
Minsk	30	71	29	97	30	100	0	0
Mahilieu	1	2	1	100	1	100	0	0
Belarus	42	100	37	88	39	93	6	14

Source: author's elaboration based on Курочкин (2017) data on TLCs.



Note: types of TLCs – A - 1;B – 2; C – 3.

Fig. 4. Location and geographic types of TLCs in Belarus, 2017

Source: author's elaboration based on Курочкин (2017) data on TLCs.

Three main types of TLCs can be defined according to their location patterns: 1 – TLCs near the regional centers; Type 2 – TLCs near international transportation corridors; 3 – TLCs near international borders (tab. 1, fig. 4). In general, 88% of all TLCs are located near regional (oblast) centers (Minsk, Brest, Viciebsk, Homiel, Hrodna). Those cities represent the transportation nodes of international and regional importance with multimodal transportation networks, industrial and trade companies, generating demand and supply for logistic services. 93% of TLCs are located exclusively in the catchment areas of international pan-European corridors II, IX and IXB. 14% of TLCs are located near the international borders of the country. It is worth to notice, that the mixed nature of the structure of types is possible and can be combined for various TLCs (for instance, the ones located near Brest city belong to types 1 and 3).

The existing territorial disproportion in the location of the existing TLCs can be explained by two main limiting factors: 1) lack of investments for construction and 2) absence of economic preferences in areas, other than free economic zones. The economic-geographical analysis of the productivity of road transportation, showed that the greatest cargo flows in 2000-2014 originated not only in oblast, but also in regional centers, such as Baranavichi, Babruysk, Barysau, Zhlobin, Mazyr, Orsha, Pinsk (see transportation nodes of regional importance on fig. 1). Those cities have potential for new TLCs, once the cargo flow generated in these cities can be consolidated with the transit freight traffic (World Bank, 2011; UNECE, 2013; Сухонос, 2012).

Of all the existing logistics centers, 45% were state-owned; the rest was created from financial sources provided by national (manufacturing companies, transportation and logistics companies, logistics operators, distributors, etc.) and foreign investors from Russia, Azerbaijan and Iran. According to the variety of services provided, the most complex logistics centers in 2016 were RUE «Beltamozhservis», JV «Brestvneshtrans», JSC «Ozertso-Logistic» and JSC «Belmagistralavtotrans». Logistical companies of Belarus provide to clients such services as transportation, declaration (customs services), warehousing, services for communications with foreign suppliers, preparation of export and import documentation, etc. (Ковалев, 2012; Курочкин, 2017).

Only 21% of TLCs, functioning in Belarus in 2016 were multimodal, with road and rail transportation networks available, while 79% had road access only. That indicates the insufficient level of integration and use of all existing transportation networks. The centers did not use the principles of network interaction in their operations, which did not allow them to manage the supply chain of products effectively.

The total area of warehousing facilities of classes «A» and «B» of all TLCs in Belarus in 2016 (more than 640 thousand sq. m.) also shows the insufficient level of development of the logistics potential in comparison with the other countries in Central and Eastern Europe. For instance, the area of warehouses of classes «A» and «B» near the city of Warsaw was about 2.6 million sq. m. (the total area of warehousing facilities of TLCs in Poland exceeded 7 million sq. m.). Uncompetitive pricing, higher than in Poland or Lithuania, has an added negative impact on operational capacity of the existing TLCs (Курочкин, 2017).

One of the indicators that evaluates the level of development of transportation and logistics services in Belarus is the World Bank's Logistics Performance Index LPI. According to 2016 LPI score, based on data from survey of logistics professionals asked about the foreign countries in which they operate, the Belarusian level of logistic system effectiveness was ranked 120th among 160 countries (tab. 2).

Tab. 2. Logistics Performance Index of Belarus 2007-2016

Year	LPI		Customs		Infra-structure		International shipments		Logistics compe-tence		Tracking & tracing		Timeliness	
	R*	S	R	S	R	S	R	S	R	S	R	S	R	S
2007	74	2.5	50	2.7	54	2.6	127	2.1	120	2.1	66	2.7	78	3
2014	99	2.6	87	2.5	86	2.6	91	2.7	116	2.5	113	2.5	93	3.1
2016	120	2.4	136	2.1	135	2.1	92	2.6	125	2.3	134	2.2	96	3.0

* R – Rank, S – Score.

Source: http://lpi.worldbank.org/international.

The most developed dimension of the Index in Belarus in 2016 was timeliness (3.0), the least – customs, and infrastructure (2.1). The comparative

analysis with neighbor countries shows that Belarus is still at the stage of formation and consolidation of the logistics industry, having significant obstacles for its development altogether with large potential for its improvement. It stands behind the neighboring countries by the level of logistics effectiveness (see the chart comparing LPIs of Poland and Belarus in 2007 and 2016, fig. 5) due to limited understanding of modern international practices and tendencies at global market of transportation and logistics. The comparison with rising scores of Poland shows that Belarus needs significant efforts to catch up in all dimensions of logistics efficiency. Better integration into global market, investments into innovations and education will significantly improve quality of services provided by national transportation and logistics services.

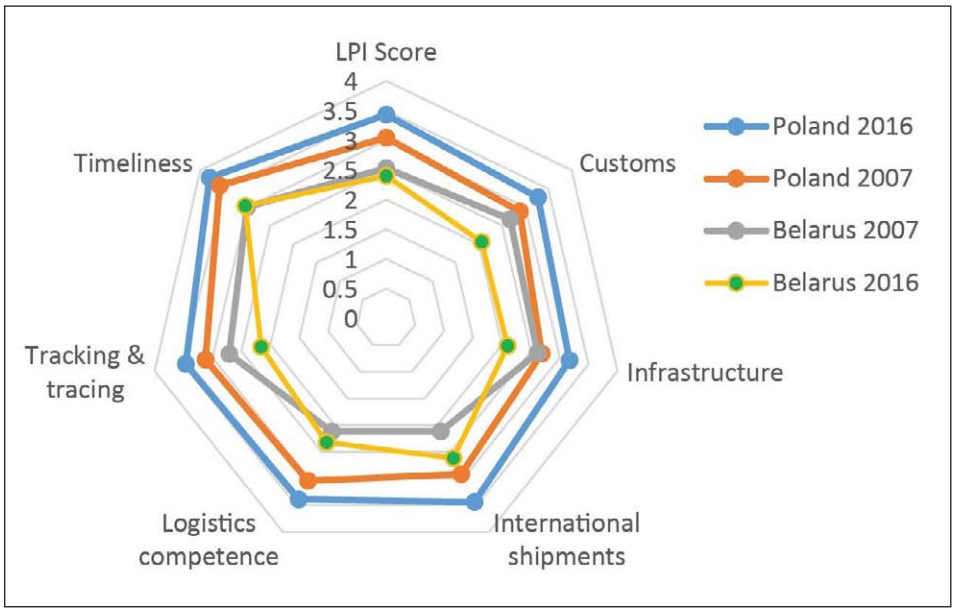


Fig. 5. LPI score for Belarus and Poland in 2000 and 2016

Source: http://lpi.worldbank.org/international.

6. Regional features of road transportation productivity in Belarus

The productivity of road transportation in Belarus had different trends for passenger and cargo transportation. Road freight traffic was growing while passenger traffic had a continuous decline with minimum passengers carried in 2009 (fig. 6).

Performance dynamics of freight road transportation in 2000-2014 is characterized by a relatively stable growth of volume of cargo carried and in turnover numbers in all regions of the country. Economic factors, such as the global economic crisis (2008-2009), accompanied by declining external trade, led to a reduction of freight transported. In 2014 majority of road freight traffic was domestic (95.4%), while the share of international traffic was only 6.2%. The temporarily growth rates due to rapid post-crisis recovery of trade volumes were the results of economic and political integration between Belarus and Russia (mail trade partner) and the countries of the Eurasian Economic Community and the Customs Union (Захман, 2011). The sector also benefited from tax liberalization, especially the abolishment of the turnover taxes (in 2007), and the growing trade with the European Union (UNECE, 2013). However, due to EU sanctions on Russia, the volumes of transit cargo traffic had decreased since 2014. The dynamics of freight traffic in Belarus was the following: 1) road transportation had overtaken rail transportation in republican structure of freight traffic volume (from 42% in 2000, to 57% in 2014; pipeline transportation was excluded from calculations); 2) the share road transportation in republican structure of freight turnover had also increased significantly (from 14% to 37%). In 2000-2016 Minsk (44% of republican traffic), Brest (14%) and Hrodna (13%) regions provided the highest freight traffic (fig. 5). Geographically cargo flows are concentrated along highways and, specifically, pan-European corridors with focus on connections between economic centers of the country.

According to the estimations of the Eurasian Economic Commission (2014), 60% of the population of Belarus, inhabitants of 120 urban and 764 rural

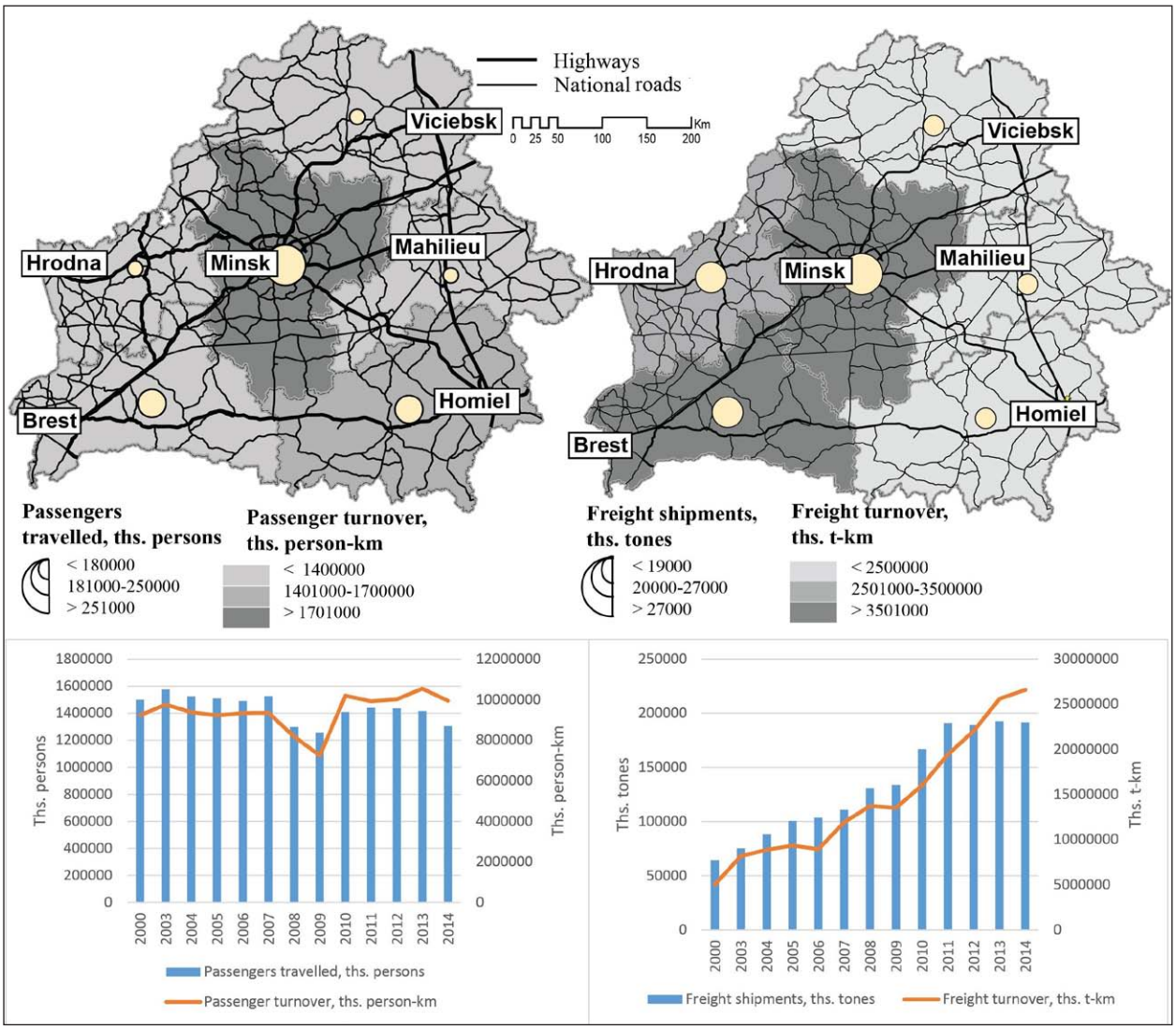


Fig. 6. Regional structure (2014) and dynamics (2000-2014) of freight and passenger traffic in Belarus

Source: author's elaboration based on National Statistical Committee (Национальный статистический комитет Республики Беларусь, 2016) data.

settlements, use road transportation services on regular basis. The result of increase in car ownership numbers was decline in numbers of passengers carried (87%) and increase in passenger turnover (107%). This, altogether with the rise of Belarusian railroad company tariffs led to growth in the share in the structure of passenger traffic volume (from 53% in 2000, to 58% in 2014) and passenger turnover (from 28% to 40%). Regional dynamics of passenger traffic was dependent on urban and suburban mobility of regional centers. The maximum passenger traffic by volume (over 200 million people per year) was in Minsk (34% of total traffic), Homiel (18%) and Brest (15%) regions. State companies affiliated with the Ministry of transportation (ИНП РАН, 2014) carried approximately 70% of all passengers. The dynamics of passenger traffic (by number of passengers) had a positive character in the Minsk, Homiel, Hrodna and Mahilieu regions; negative – in Brest and Viciebsk. The largest passenger turnover (over 1,400 million pass-km) was in Minsk and Homiel regions (fig. 6).

7. Summary

This article highlighted some current tendencies of the road transportation development in Belarus, the landlocked country with high transit potential due to connecting geographic location for trade flows between Europe and Asia.

The key findings indicate that spatial evolution of the major roads network had a period of stagnation in 2000-2010, caused by insufficient financial support from internal and external sources. That period ended with construction of P98 and M14 roads, what led to

formation of the new 6th topology layer of the circuital structure of the network and increase in transportation accessibility of the areas of construction.

Furthermore, in order to improve current state of TLCs development, new policies and approaches towards uncompetitive pricing, uneven spatial distribution and management of warehousing facilities capacities should be implemented. The analysis had shown that the logistics sector of Belarus needs more efforts to integrate transportation systems in order to improve its operational efficiency and attract potential users.

Finally, cargo and passenger traffic is highly influenced by a wide range of internal and external socio-economic and geopolitical factors. Volumes and distances of cargo traffic by road transportation are increasing in all regions of the country (however, there was a reduction after EU sanctions on Russia). Volumes of passenger traffic are decreasing, although, the travel distances are increasing.

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