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Globalization and the development of logistics infrastructure of the freight transport by road

Abstract

Development of countries and regions is possible thanks to their adequate infrastructure. The globalization of economic processes has contributed to the increase in the intensity of the movement of all kinds of goods, which is possible due to the transport infrastructure. Transport is one of the functional systems of logistics, which covers all activities consisting in the movement of material goods, people and information, in time and space, with appropriate technical equipment. Thus, it constitutes an element of the technical infrastructure of logistics. Road transport is the main branch of Polish transport both in terms of the mass of and the revenues from the freight. Therefore the authors have conducted an in-depth study of the logistics infrastructure of the freight transport by road, not only for Poland, but also for other European countries. The purpose of this article is to analyze the concentration of the elements of the road transport infrastructure and to examine the competitiveness of companies providing road transport services in selected European countries in the years 2001-2011, and to examine the road network saturation. The following indices were used in the analysis: Herfindahl-Hirschman concentration index, location quotient, weighted average rate of road network density and Engel's road network density index. The Herfindahl-Hirschman index measures the concentration and determines the estimated level of concentration in a given industry and the level of competitiveness on a given market. The location quotient determines the level of the analyzed variable in relation to the so-called reference variable and allows one to determine whether the analyzed area has a higher level of the variable in a given section, compared to the average for the reference area, whether there is a potential shortage of certain activities in the examined area, or whether the level of a feature in a given area is sufficient. Weighted average rate of the road network density refers to the density of the road network in relation to the area and population of a given country. The Engel's network density ratio in turn takes into account, apart from the area and population, the size of the transported goods. The performed analyses provide information on the uniformity of equipment in the road transport infrastructure of the

examined countries and show similarities and differences in the road network saturation. The applied measures allow one to compare the analyzed countries in terms of the discussed variables, and in particular: the total length of motorways (kilometers), annual road freight transport (thousands of tonnes), length of e-roads (kilometers) length of other roads (kilometers), number of goods road transport companies.

Keywords: transport logistics infrastructure, Herfindahl-Hirschman concentration index, location quotient, weighted average rate of road network density, Engel's road network density index.
JEL code: L90

Introduction - Globalization and its impact on the development of logistics

The globalization of economic processes has influenced the development of logistics. One talks increasingly more often about the global logistics, the concept of which takes into account the following trends in the European and world economy:[1]

- increasing number of production connections in regional and intercontinental systems,
- increasing specialization of production and ensuing limitation of the scope of manufacturing processes (reduced degree of diversification of the production range),
- shortening the task performance time and increasing the flexibility of production processes,
- extending the application of delivery stream flow management strategies in order to minimize the level of inventory,
- sourcing raw materials, semi-finished products, parts and components for the global market.

These changes result in the development of logistics networks. A logistics network is defined as "a set of nodes (for instance, warehouses or transshipment points) and transport connections, and resulting from being subject of a planning process of an economic actor or association of actors deciding together"[2]. The logistics network therefore focuses on the processes of movement of all kinds of resources. Movement of people, goods, services and information is in turn an essential element of the society.[3]

[1]Skowronek C., Sarjusz-Wolski Z., Logistyka w przedsiębiorstwie, Polskie Wydawnictwo Ekonomiczne, Warsaw 2003, p. 87.
[2]Liedtke G., Friedrich H., Generation of logistics networks in freight transportation models, Transportation 39, 2012, p. 1337.
[3]Poumanyvong P., Kaneko S., Dhakal S., Impacts of urbanization on national transport and road energy use: Evidence from low, middle and high income countries, Energy Policy 46, 2012, p. 268.

Performance of the movement processes requires adequate infrastructure equipment.[4] Infrastructure is a key factor in the development of countries and regions. Both the quality and quantity of the infrastructure has a significant impact on the economic activity and its efficiency. In particular, the transport infrastructure fosters regional cooperation and integration.[5] Transport infrastructure is the basis for the development of industry and trade. It has a significant impact on the economic growth rate, which is dependent on the number of ports, roads, railways and airports.[6] Transport infrastructure leads to economic growth by:[7]

1. increased demand for goods and services through investment in the infrastructure alone,
2. shortening the time of passenger and freight transport, which leads to increased profits by saving time and cost, to increased access to remote markets and stimulation of the local market, and to the reduction of the level of inventories in the companies,[8]
3. attracting foreign investors and developing industrial agglomerations, and ensuing increased work efficiency thanks to the concentration of economic activity.[9]

This paper focuses on the analysis of the logistics infrastructure of the freight transport by road. The authors have analyzed concentration of the transport infrastructure in selected European countries in the period from 2002 to 2011. They have also examined the road network density in that period.

The concept of transport logistics infrastructure

Transport is one of the functional systems of logistics. Transport supports the processes of delivery and distribution[10]. Implementation of the transport processes is also part of activities in the area of reverse logistics[11]. Transport encompasses all activities consisting in the movement of all kinds of resources, such as material goods, people and information, in

[4]Frankowska M., Jedliński M., Efektywność system dystrybucji, PWE, Warszawa 2011, p. 106.
[5]Yamamoto T., Talvitie A., Transport infrastructure and services: an Asia and developing word, Transportation 38, 2011, p. 715.
[6]Schuckmann S.W., Gnatzy T., Darkow I.-L., von der Gracht H.A., Analysis of factors influencing the development of transport infrastructure until the year 2030 - A Delphi based scenario study, Technological Forecasting and Social Change 79, 2012, p. 1373.
[7]Hong J., Chu Z., Wang Q, Transport infrastructure and regional economic growth: evidence from China, Transportation 38, 2011, p.737-738.
[8]Nowakowska-Grunt J., Kurp A., Systemy transportu i zapasów na przykładzie elektrowni cieplnych, Logistyka no. 6, 2012, p.204-207.
[9]Barcik R., Bylinko L., Problemy zarządzania miejską infrastrukturą drogową w Polsce Wybrane Zagadnienia Logistyki Stosowanej 2007 no. 4 / Komitet Transportu Polskiej Akademii Nauk, p. 244-249
[10]Ziółkowska B., Logistyczny proces dystrybucji jako obszar kształtowania relacji z klientem, [in]: Nowoczesność przemysłu i usług. Relacje i wartość w strategiach zarządzania przedsiębiorstwem, Ed. Pyka J., TNOiK, Katowice, 2008, p. 368.
[11]Sadowski A., Ekonomiczne i ekologiczne aspekty stosowania logistyki zwrotnej w obszarze wykorzystania odpadów, Wyd. UŁ, Łódź 2010, J. Szołtysek, Logistyka zwrotna. Reverse logistics, Instytut Logistyki i Magazynowania w Poznaniu, Poznań 2009.

time and space, by means of appropriate technical equipment.[12] Such an understanding of transport makes it part of the technical infrastructure of logistics[13], which is necessary for the logistics processes[14]. Due to its universal role, transport functions and develops as being subordinated to the purposes and principles of the socio-economic policy, pursued by a given country".[15]

In economy, the term "infrastructure" does not have a single, universal definition, due to a large variety of its components, as well as its historical volatility. It is assumed that in the general sense, infrastructure is the foundation of a given structure or system, consisting of a variety of facilities, equipment, and other elements, which are necessary for a proper functioning of the entire system.[16] Infrastructure is usually divided into two sub-categories: economic and social one.[17] Economic infrastructure, also called technical one, enables one to provide e.g. communication, transport, energy, heat and water supply, waste disposal and sewage treatment services. Social infrastructure on the other hand serves the purpose of satisfying the social and cultural needs, and it includes various types of educational institutions (such as kindergartens, schools), institutions providing health-related services (e.g. health centers, hospitals), entities providing access to the broader culture (e.g. theaters, libraries), and institutions responsible for the protection of the law and security (such as courts, the police, the army). Equipment and institutions providing transport services are included in the economic infrastructure. Transport logistics infrastructure includes measures and conditions enabling physical movement of persons and goods, in order to ensure continuity of production and services.[18] From the point of view of logistics, transport infrastructure should ensure efficiency of the flow and reduce the transport costs[19]. Efficiency of the flow allows one to deliver a particular product on time, to the right place, in accordance with the requirements of the supplier or recipient. Transport costs are considered to be an important determinant of corporate internationalization.[20] Minimization of transport costs can be achieved by an adequate selection of the type of transport and a particular means of

[12]Skowronek C., Sarjusz-Wolski Z., Logistyka w …, op. cit, p. 86.
[13]Zawada M., Przesył i dystrybucja energii elektrycznej w Polsce, Logistyka no. 5/2011, p. 350-353.
[14]Mesjasz-Lech A., Process based organization and eco-logistics, [in]: Enterprises Facing New Economic Challenges. Management - Development - Restructuring. Ed. Borowiecki R. & Jaki A., Department of Economics and Organization of Enterprises, Cracow University of Economics, Cracow 2010, p. 142.
[15]Brzozowska A., Organization of transport. Theoretical approach, [in]: Economical and organizational aspects of transportation processes, Faculty of Management Czestochowa University of Technology, Częstochowa 2010, p.7.
[16]Korombel A., Ryzyko w finansowaniu działalności inwestycyjnej metodą project finance, Difin Warsaw 2007, p. 15-19.
[17]Domańska A., Wpływ infrastruktury transportu drogowego na rozwój regionalny, Wydawnictwo Naukowe PWN, Warsaw 2006, p. 23.
[18]Knop L., The advancement level of clusters in the Śląskie Voivodeship, [in]: Clusters politics management good clustering practices in the world, Ed. Bojar E., TNOiK, Toruń 2009, p. 182.
[19]Skowronek C., Sarjusz-Wolski Z., Logistyka w…, op. cit., s. 86.

transport, as well as optimization of the transport routes and time. Therefore the development of transport logistics infrastructure primarily aims at:[21]

- elimination of communication bottlenecks,
- reduction or elimination of congestions,
- reduction of the transport time and costs,
- increase of the communication availability,
- creation of favourable conditions for regional development,
- stimulation of the economic growth.

General characteristics of the transport logistics infrastructure in Poland, with particular focus on the freight transport by road.

Transport logistics infrastructure includes five basic branches of transport:

- rail transport,
- road transport,
- pipeline transport,
- river and sea transport,
- air transport.

Figure 1 shows detailed breakdown of the components of the transport logistics infrastructure.

[20]Naudé W., Matthee M., The impact of transport costs on new venture Internationalisation, Journal of International Entrepreneurship 9, 2011, p. 63.
[21]Gołembska E. (ed.), Współczesne kierunki rozwoju logistyki, Polskie Wydawnictwo Ekonomiczne, Warsaw 2006, p. 110.

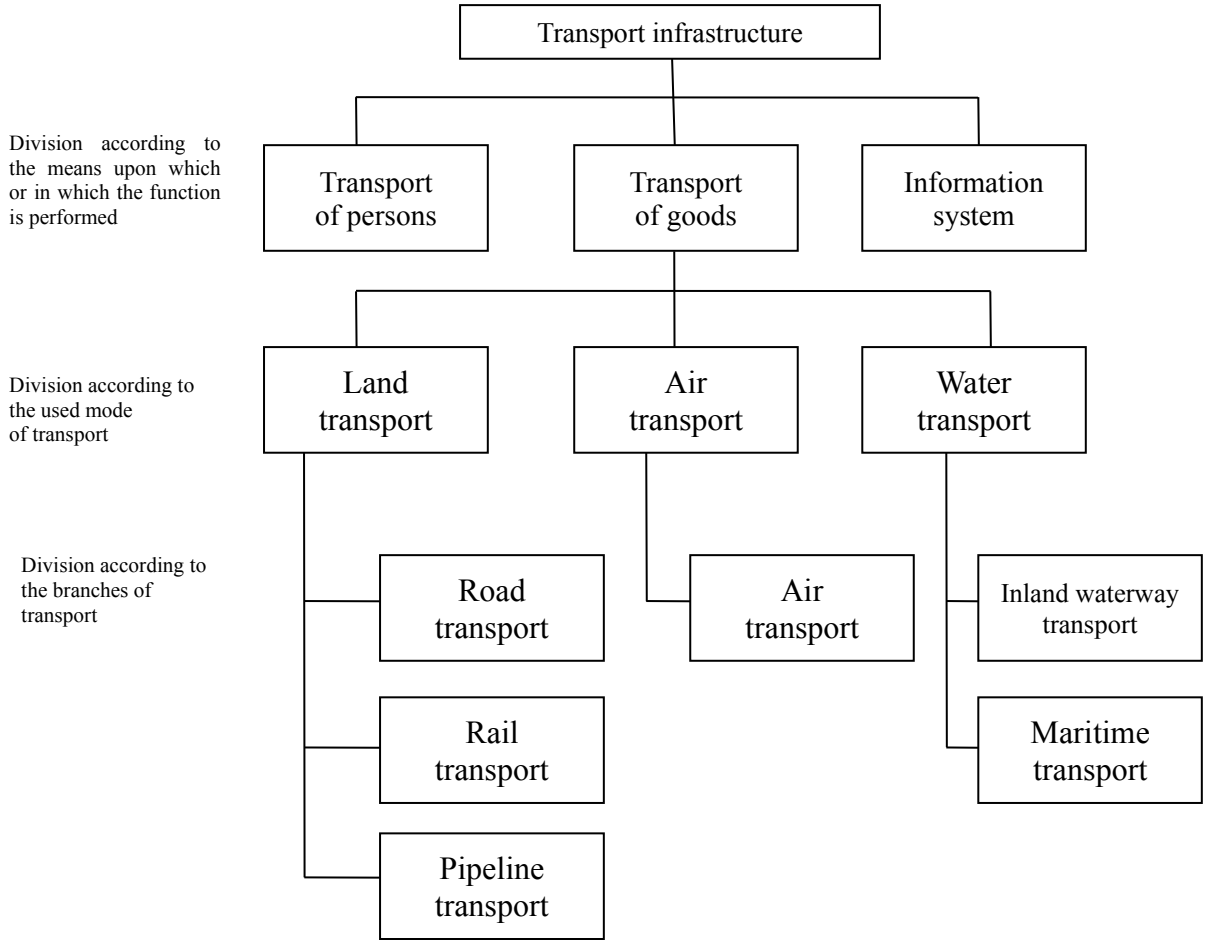

Figure 1 Transport logistics infrastructure.

Source: own study based on Skowronek C., Sarjusz-Wolski Z., Logistyka w przedsiębiorstwie, Polskie Wydawnictwo Ekonomiczne, Warsaw 2003, p 85, Pfohl H.-Ch., Systemy logistyczne, Biblioteka Logistyka, Poznań 1998, p 165 .

From the point of view of logistics processes, the following elements seem to be an important measure of changes in the transport infrastructure:

- weight of the transported cargo,
- revenue from the freight.

Tables 1-2 include relevant data for the years 2010 and 2011.

Table 1 Transport of goods by mode of transport in Poland in 2011.

Modes of transport	Tonnes			Tonne-kilometres			Average distance travelled by 1 tonne of goods, kilometres
	thousand	2010=100	in percent	million	2010=100	in percent	
Total	1 935 149	106.1	100	317 902	103.2	100	x
Railway transport	271 577	103.3	13	53 841.4	110.1	16.9	216
Road transport	1 596 209	107	83.5	218 888.4	102.2	68.9	137
Air transport	45	110.3	0	128.6	112.5	0	2 863
Pipeline transport	54 488	96.9	2.8	22 794.2	94.4	7.2	418
Inland waterway transport	5 093	99.1	0.3	908.9	88.2	0.3	178
Maritime transport	7 737	92.5	0.4	21 340.6	107.9	6.7	2 758

Source: Transport – activity results in 2011, Statistical Information and Elaboration, Central Statistical Office, Warsaw 2012.

The largest share of the cargo transport in the total transport is observed for the road transport, both in tonnes and tonne-kilometers This share amounts to 83.5% for tonnes and 68.9% for tonne-kilometers. Rail transport is the second largest branch of transport when it comes to the size of the cargo transport, and its share amounts to 13% for tonnes and 16.9% for tonne-kilometers. Other branches have a negligible share in the cargo transport.

Table 2 Share of revenues from the cargo transport by mode of transport in the total transport revenues in 2010-2011.

Modes of transport	2010	2011
Land and pipeline transport	98.3	98.2
of which road transport	84.4	83.9
Air transport	0.8	0.9
Water transport	1	0.9
maritime transport	0.8	0.7
inland waterway transport	0.2	0.2

Source: Transport – activity results in 2011, Statistical Information and Elaboration, Central Statistical Office, Warsaw 2012.

The main branch of transport in Poland in terms of revenue from cargo transport is land and pipeline transport, and revenues from it account for over 98% of total transport revenues. Road transport had an 84.4% share in 2010 and 83.9% share in 2011. Road transport is therefore the most commonly used mode of transport in Poland, also due to the transport time and ability to deliver cargo directly to the destination. It should also be remembered that transport has an impact on the environment. Transport and guidelines for it are part of the environmental management system, which is an attractive measure of competitive position of the entities.[22] Thus transport may become a criterion for the assessment of the competitiveness of regions.

Measures of concentration in statistical analysis

Numerical detection of concentration strength is particularly important in economic research. Concentration is understood as the degree of "uneven distribution of the total number of measurable features of the variable between particular groups of individuals of the analysed statistical population"[23]. Taking into account the concentration strength, one can distinguish two situations:

1. a total lack of concentration of the phenomenon - one can see an even distribution of the phenomenon in the analysed population,
2. concentration of the phenomenon - one can see an uneven distribution of the phenomenon in the analysed population.

Analysis of the concentration was applied in the study of inequality in the distribution of the elements of the road transport infrastructure in selected European countries.

Studies on the mechanism of the impact of market structure on the behavior of competing entities operating on this market have showed that a higher concentration results in lower competition. Thus high market concentration may lead to higher prices of the offered goods and services, with a higher profitability of the operation of their providers.[24] Therefore it is important to use measures of concentration in the analysis of the competitiveness of the market of certain services. Due to the fact that part of the road transport infrastructure includes companies providing services in the field of road transport, and therefore operating on the market of these services, one used the Herfindahl-Hirschman Index to study its concentration.

[22]Kościelniak H., Brendzel-Skowera K., System EMAS a konkurencyjność polskich przedsiębiorstw, Przegląd Organizacji no, 7-8/2010, p. 35-40.
[23]Luszniewicz A., Słaby T., Statystyka, Wydawnictwo C.H. Beck, Warsaw 2003, p. 59.
[24]Jackowski K., Kowalewski O., Koncentracja działalności sektora bankowego w Polsce w latach 1994-2000; Praca badawcza ramach projektu badawczego No. 5H02C 041 21; www.nauka.opi.org.pl.

Herfindahl-Hirschman Index (HHI) is defined as the sum of squares of market shares, and is calculated according to the following formula:[25]

$$HHI = \sum_{i=1}^{n} z_i^2,$$

where z_i means a share of the value of the analysed feature for the i-th object in the total value of the analysed feature for all analysed n units. The HH index assumes values in the range of (1/n; 1), and the higher its value, the greater the concentration. According to the recommendations of the FERC (Federal Energy Regulatory Commission) in the United States the value of the index:

- less than 0.10 indicates a lack of concentration,
- from 0.10 to 0.18 indicates a moderately high concentration,
- above 0.18 indicates a very high concentration.

The Herfindahl-Hirschman Index is used to determine an estimated level of concentration in a given branch of industry and the level of competition on a given market.[26] The Herfindahl-Hirschman index is a special case of the Hannah-Kay index, defined by the formula:

$$HK = \sum_{i=1}^{n} z_i^a ,$$

where the a parameter is the so-called flexibility parameter, chosen individually by the person conducting the analysis. This parameter has a value in the range (1.5; 2.5).

The location quotient allows one to study spatial concentration and is therefore applied in regional studies and analyses of concentration of the studied phenomenon in a specific region. This quotient determines the level of the analysed variable compared to the so-called reference variable, according to the formula:[27]

$$LQ = \frac{E_{ib} / E_b}{E_{ir} / E_r},$$

where: LQ – location quotient, E_{ib} – value of the variable in the i sector in the b area, E_b – value of the variable in all sectors in the b area, E_{ir} – value of the variable in the i sector in the r reference area, E_r – value of the variable in all sectors in the r reference area.

The location quotient can assume:

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[25]Nieszporska S., Analiza koncentracji w badaniach statystycznych, [in]: Nowoczesne instrumenty zarządzania, Ed. Mesjasz-Lech A., Sekcja Wydawnictwa Wydziału Zarządzania Politechniki Częstochowskiej, Częstochowa 2009, p. 21.

[26]Zawada M., Koncentracja rynku energii elektrycznej w krajach Unii Europejskiej, [in]: Kreatywność i innowacyjność w unowocześnianiu przemysłu i usług, Ed. Pyka J., TNOiK Branch in Katowice, Katowice 2009, p. 314.

[27]Nieszporska S., Analiza koncentracji…, op. cit., p. 23.

- a value greater than 1, which means that the analysed area has a higher level of the variable in a given section than in the reference area,
- a value smaller than 1, which indicates a potential shortage of certain activities in the analysed region,
- a value of 1, which indicates a sufficient level of the feature in a given area.

Analysis of concentration of the logistics infrastructure of road freight transport in Europe

The purpose of this analysis is to determine the concentration of the elements of road transport infrastructure and to examine the competitiveness of companies providing services in the field of road transport in selected European countries. The following features were analysed: the total length of motorways (kilometers), annual road freight transport (thousands of tonnes), length of e-roads (kilometers), length of other roads (kilometers), number of goods road transport enterprises. The data on which the analysis was based, cover the years 2002 - 2011. Table 3 shows the values of Herfindahl-Hirschman concentration indexes for the specified features in the analysed years. One has analysed the values of variables in selected European countries before and after the enlargement of the European Union by 10 countries in 2004. Depending on the availability of the data, the following countries were analysed: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, the Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Liechtenstein, Norway, Switzerland, Croatia.

Table 3. The Herfindahl-Hirschman Index for specific features.

Variable	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Length of motorways[I]	0.123	0.123	0.121	0.122	0.120	0.121	0.118	0.117	0.118	0.118
Length of e-roads[II]	0.081	0.081	0.080	0.080	0.080	0.080	0.082	0.085	0.084	0.083
Length of other roads[III]	0.108	0.107	0.108	0.105	0.105	0.105	0.104	0.105	0.105	0.105
Annual road freight transport[IV]	0.090	0.090	0.089	0.088	0.090	0.090	0.088	0.088	0.090	0.095
Number of goods road transport enterprises[V]	0.160	0.158	0.160	0.159	0.158	0.158	0.159	0.149	0.150	0.151

I – the analysis did not include Greece, Malta, Lichtenstein, II – the analysis did not include Belgium, Germany, Ireland, Greece, Spain, France, Italy, Luxemburg, Netherlands, Liechtenstein, Norway, III – the analysis did not include Germany, Greece, IV – the analysis did not include Malta, Iceland, V – the analysis did not include Belgium, Denmark, Germany, Ireland, Greece, Luxembourg, Netherlands, Portugal, United Kingdom, Switzerland, Croatia.

Source: own study based on data from Eurostat, http://epp.eurostat.ec.europa.eu.

Moderate concentration is observed for all years for the following features: length of motorways, length of other roads and number of goods road transport. The highest values of the HH indexes in this group of variables could be observed for the number of goods road transport. On the other hand, the length of roads and annual road freight transport show no concentration. The presented data also show a slight decrease in the analysed years in the inequality of concentration with respect to the length of motorways, length of other roads and number of goods road transport enterprises. This means that the entry of more countries into the European Union resulted until 2011 only in a slight improvement in the development of road transport infrastructure in terms of the road length and the number of companies providing services in the field of road transport. However the launched infrastructure investments will bring the expected results in the form of new roads in the years to come.

Values of the Herfindahl-Hirschman Index for the number of goods road transport enterprises below 0.18 indicate a competitive global transport services market, which covers the analysed countries. Therefore there is no country that would have a dominant position in the field of transportation services provision.

The concentration analysis was also made with the application of the location quotient, which was calculated for the following countries: Bulgaria, Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Switzerland, Croatia.

Tables 4-6 present values of this quotient for particular features, countries and years.

Table 4 *LQ* for the length of motorways.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bulgaria	0.5091	0.5038	0.4945	0.4889	0.5657	0.5862	0.5814	0.5756	0.5979	0.6228
Czech Republic	0.1372	0.1351	0.1385	0.1416	0.1526	0.1551	0.1617	0.1688	0.1690	0.1684
Denmark	0.4787	0.4734	0.4607	0.4557	0.4686	0.4708	0.4734	0.4687	0.4661	0.4645
Estonia	0.0634	0.0618	0.0589	0.0567	0.0548	0.0516	0.0551	0.0525	0.0594	0.0591
Cyprus	0.7987	0.7786	0.7389	0.7474	0.6716	0.6594	0.6502	0.6406	0.6319	0.6043
Latvia	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lithuania	0.1832	0.1772	0.1712	0.1690	0.1215	0.1179	0.1165	0.1149	0.1132	0.1118
Hungary	0.1133	0.1138	0.1161	0.1284	0.1544	0.1651	0.1975	0.1967	0.1956	0.1949
Austria	0.5216	0.5237	0.5094	0.5033	0.4918	0.4809	0.4773	0.4654	0.4516	0.4500
Poland	0.0370	0.0361	0.0476	0.0468	0.0547	0.0535	0.0612	0.0671	0.0638	0.0781
Portugal	4.3772	4.3289	4.2124	4.1670	5.3897	5.4152	5.4643	5.4326	5.4638	5.3446
Romania	0.0495	0.0455	0.0954	0.0938	0.0852	0.1016	0.0995	0.1123	0.1150	0.1191
Slovenia	0.4024	0.4176	0.4109	0.4784	0.4741	0.4625	0.5493	0.5829	0.5964	0.5921
Slovakia	0.5487	0.5535	0.5443	0.2379	0.2320	0.2524	0.2637	0.2657	0.2870	0.2855
Finland	0.1943	0.2072	0.2008	0.2097	0.2058	0.2001	0.2098	0.2131	0.2173	0.2171
Sweden	0.3669	0.3737	0.3845	0.3788	0.3824	0.3872	0.3914	0.3788	0.3767	0.3754
United Kingdom	0.2943	0.2906	0.2895	0.2864	0.2779	0.2720	0.2704	0.2678	0.2662	0.2661
Iceland	0.0000	0.0000	0.0000	0.0277	0.0271	0.0265	0.0263	0.0260	0.0259	0.0258
Switzerland	0.6378	0.6349	0.6134	0.6026	0.6000	0.5966	0.5918	0.5950	0.5918	0.5933
Croatia	0.5174	0.6230	0.8120	0.8548	0.9126	0.9628	1.0320	1.0782	1.1009	1.0970

Source: own study based on data from Eurostat, http://epp.eurostat.ec.europa.eu.

The location quotient has reached a value greater than unity in all analysed years only in Portugal, which means that the country has more motorways than the average for the analysed countries. In the years 2008-2011 the *LQ* for the length of motorways reached a value greater than unity in Croatia (this value has been increasing steadily since 2002). For the remaining countries, the value of this quotient was less than unity throughout the analysed period, from which one can infer that the length of motorways there is lower than the average for the analysed area of Europe. This quotient had the lowest value for Estonia, Poland, Romania and Iceland, which shows that these countries have the fewest motorways, compared to the average for the analysed countries. Latvia did not report any motorways at all.

Table 5 *LQ* for the length of e-roads.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bulgaria	6.0338	6.0124	5.9529	6.0280	6.0617	6.0165	5.9756	5.9199	5.9722	5.9381
Czech Republic	0.8998	0.8914	0.8833	0.8949	0.8886	0.8827	0.8796	0.8707	0.8899	0.8870
Denmark	0.5793	0.5769	0.5714	0.5790	0.5808	0.5716	0.5670	0.5617	0.5672	0.5654
Estonia	0.3603	0.3538	0.3503	0.3348	0.3347	0.3305	0.3262	0.3232	0.7537	0.7504
Cyprus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Latvia	0.1502	0.1522	0.1517	0.1530	0.1548	0.1535	0.1529	0.1510	0.1537	0.1536
Lithuania	0.8710	0.8359	0.9174	0.9276	0.9193	0.9063	0.8972	0.8862	0.8826	0.8711
Hungary	0.5684	0.5561	0.5740	0.5851	0.5950	0.6087	0.5007	0.4998	0.5046	0.5030
Austria	0.9290	0.9260	0.9115	0.9200	0.9290	0.9194	0.9083	0.8886	0.8636	0.8608
Poland	0.6559	0.6447	0.6348	0.6399	0.6438	0.6398	0.6351	0.6278	0.6001	0.5891
Portugal	7.1732	7.1430	7.0758	7.1690	6.7939	6.7434	6.6618	6.5374	6.5892	6.4447
Romania	3.1836	3.0857	3.2864	3.3137	3.1191	3.1180	3.1029	3.1222	3.1440	3.0880
Slovenia	0.7202	0.7149	0.7128	0.7307	0.7247	0.7183	0.7107	0.7032	0.7078	0.7056
Slovakia	2.9469	3.5716	3.5369	1.5308	1.5440	1.5560	1.5252	1.5079	1.1380	1.5341
Finland	1.7845	1.7799	1.7555	1.7703	1.7838	1.7631	1.7534	1.7233	1.7081	1.6809
Sweden	1.6425	1.6347	1.6176	1.6389	1.6459	1.6351	1.9490	2.0735	2.0941	2.0873
United Kingdom	0.3999	0.3975	0.3979	0.4064	0.4039	0.4013	0.3991	0.3953	0.4030	0.4016
Iceland	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Switzerland	0.8632	0.8595	0.8515	0.8917	0.9166	0.9113	0.9053	0.8959	0.9048	0.9017
Croatia	3.0246	3.0118	2.9835	3.0137	3.0239	3.2639	3.2215	2.9182	2.9477	2.9382

Source: own study based on data from Eurostat, http://epp.eurostat.ec.europa.eu.

The situation is different for the length of e-roads. In this case the quotient has reached values higher than unity throughout the entire analysed period for Bulgaria, Portugal, Romania, Slovakia, Finland, Sweden and Croatia. It can therefore be concluded that in these countries the length of e-roads is much higher than the average for the analysed area of Europe. In the case of Bulgaria, Portugal, Romania, Slovakia, Finland and Croatia, the *LQ* average value has been decreasing slightly year to year, in the analysed period, while for Sweden one can observe an increase in the average value of this quotient. *LQ* reached the lowest value in case of Latvia and the UK, which means that in these countries the length of e-roads is lower than the average for the analysed countries.

Tabela 6. *LQ* for the length of other roads.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bulgaria	0.4619	0.4625	0.4608	0.4576	0.4564	0.4542	0.4583	0.4579	0.4581	0.4590
Czech Republic	0.5295	0.5302	0.5283	0.5244	0.5244	0.5223	0.5268	0.5261	0.5267	0.5280
Denmark	0.5280	0.5287	0.5268	0.5231	0.5228	0.5206	0.5251	0.5246	0.5254	0.5266
Estonia	0.5371	0.5379	0.5360	0.5325	0.5326	0.5306	0.5353	0.5348	0.5303	0.5316
Cyprus	0.5299	0.5308	0.5292	0.5252	0.5262	0.5241	0.5289	0.5284	0.5293	0.5310
Latvia	0.5406	0.5413	0.5394	0.5356	0.5357	0.5335	0.5383	0.5378	0.5385	0.5398
Lithuania	0.5291	0.5302	0.5273	0.5236	0.5246	0.5226	0.5274	0.5269	0.5278	0.5292
Hungary	0.5338	0.5346	0.5324	0.5284	0.5279	0.5254	0.5307	0.5301	0.5309	0.5322
Austria	0.5231	0.5237	0.5219	0.5182	0.5183	0.5163	0.5210	0.5207	0.5221	0.5233
Poland	0.5340	0.5348	0.5328	0.5290	0.5290	0.5269	0.5315	0.5308	0.5321	0.5332
Portugal	0.3875	0.3880	0.3866	0.3839	0.3670	0.3633	0.3655	0.3655	0.3651	0.3692
Romania	0.5034	0.5051	0.4997	0.4964	0.4992	0.4968	0.5012	0.4998	0.5006	0.5023
Slovenia	0.5275	0.5279	0.5259	0.5209	0.5210	0.5190	0.5221	0.5209	0.5214	0.5227
Slovakia	0.4984	0.4912	0.4894	0.5153	0.5154	0.5127	0.5173	0.5167	0.5217	0.5181
Finland	0.5179	0.5184	0.5166	0.5129	0.5130	0.5111	0.5155	0.5150	0.5160	0.5176
Sweden	0.5169	0.5175	0.5153	0.5117	0.5116	0.5094	0.5100	0.5079	0.5086	0.5098
United Kingdom	0.5330	0.5337	0.5317	0.5279	0.5281	0.5260	0.5307	0.5301	0.5309	0.5321
Iceland	0.5424	0.5432	0.5413	0.5370	0.5370	0.5349	0.5397	0.5392	0.5399	0.5412
Switzerland	0.5220	0.5227	0.5209	0.5169	0.5166	0.5144	0.5190	0.5184	0.5191	0.5203
Croatia	0.4979	0.4969	0.4918	0.4875	0.4865	0.4804	0.4836	0.4854	0.4856	0.4868

Source: own study based on data from Eurostat, http://epp.eurostat.ec.europa.eu.

In the case of the "length of other road" variable, the *LQ* values are lower than unity for all countries in each and every analysed year. The lowest value of the *LQ* for the length of other roads was seen in the case of Portugal. For the remaining countries, the quotient values are similar and amount to about 0.5 throughout the analysed period.

Comparison of countries in terms of their equipment with road transport infrastructure was also made on the basis of indicators that measure the density of the road network, in particular the *Wg* index (weighted average rate of saturation of the road network) and the *G* index (Engel network density index) as defined by the following formula:[28]

$$Wg = \sqrt{\frac{l \times l}{h \times pow}},$$

where: l - the length of roads in kilometers, *pow* - area in km^2, h - the number of inhabitants in thousands,

$$G = \frac{l}{\sqrt[3]{pow \times L \times Ł}},$$

where: l - the length of roads in kilometers, *pow*- area in km^2, L - population, $Ł$ – loads.

[28]Domańska A., Wpływ infrastruktury…, op.cit., p. 27.

Tables 7-8 presents results for the following countries: Bulgaria, Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Croatia.

Table 7 Weighted average rate of saturation of the road network (*Wg*) for selected European countries in the years 2002-2011.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bulgaria	0.7534	0.7551	0.7575	0.7599	0.7648	0.7686	0.7708	0.7727	0.7760	0.7878
Czech Republic	4.5936	4.6160	4.6160	4.6118	4.6769	4.6620	4.6446	4.6329	4.6280	4.6332
Denmark	4.8021	4.7956	4.7894	4.7828	4.8047	4.8458	4.8403	4.8274	4.8167	4.8068
Estonia	6.9510	7.0627	7.0773	7.5110	7.5917	7.6537	7.7073	7.7085	7.7849	7.7954
Cyprus	4.5224	4.5480	4.6097	4.5874	4.5935	4.5472	4.5488	4.5507	4.5064	4.6357
Latvia	4.9364	4.8658	4.8473	4.8838	4.8845	4.9120	4.9117	4.9411	4.9165	5.1166
Lithuania	5.2461	5.3724	5.4280	5.4560	5.5037	5.5688	5.6040	5.6401	5.7394	6.0332
Hungary	5.2878	5.3028	5.3124	5.3203	5.3299	5.3385	6.5795	6.5424	6.5498	6.5591
Austria	4.1840	4.1735	4.1794	4.1701	4.1563	4.1981	4.1870	4.2441	4.4031	4.3942
Poland	3.4637	3.5102	3.5325	3.5517	3.5644	3.5693	3.5724	3.5792	3.7795	3.8203
Portugal	0.4772	0.4755	0.4742	0.4731	0.4941	0.4938	0.4964	0.5000	0.5001	0.5114
Romania	1.0943	1.1783	1.1051	1.1126	1.1965	1.2122	1.2295	1.2327	1.2390	1.2590
Slovenia	6.1555	6.1342	6.1409	6.1421	6.1428	6.1487	6.1694	6.1497	6.1560	6.1484
Slovakia	1.1696	1.1890	1.1892	2.7867	2.7871	2.7899	2.7882	2.7868	2.7246	2.7604
Finland	2.5655	2.5733	2.5808	2.5892	2.5962	2.6076	2.5992	2.6161	2.5927	2.6163
Sweden	2.2960	2.2930	2.2910	2.2863	2.2917	2.2863	2.2956	2.3836	2.3735	2.3645
United Kingdom	3.5196	3.5184	3.4719	3.4344	3.4772	3.4707	3.4562	3.4448	3.4322	3.4200
Croatia	1.9167	1.9170	1.9168	1.9225	1.9458	1.9753	1.9893	1.9838	1.9858	1.9889

Source: own study based on data from Eurostat, http://epp.eurostat.ec.europa.eu.

The *Wg* index relates road network saturation to the area and population of a given country. In the analysed period the highest rate of this index was observed for the Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary, Austria and Slovenia. Therefore these countries have the most kilometers of roads per area unit and 1,000 thousand inhabitants. Besides, in the case of countries with the highest value of this index, one can observe its average annual growth, with the exception of Slovenia, for which the length of roads in relation to the area and population declines by an average of 0.013% from year to year. In the analysed period this index assumed the smallest value for Bulgaria and Portugal.

Table 8 Engel's network density index (*G*) for selected European countries in the years 2002-2011.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bulgaria	0.0438	0.0438	0.0439	0.0440	0.0443	0.0461	0.0423	0.0450	0.0470	0.0469
Czech Republic	0.1796	0.1840	0.1816	0.1822	0.1871	0.1855	0.1881	0.1977	0.2002	0.2016
Denmark	0.2002	0.2013	0.2059	0.2006	0.2062	0.2064	0.2079	0.2263	0.2183	0.2128
Estonia	0.4518	0.4588	0.4702	0.4769	0.4626	0.4407	0.4355	0.4879	0.5089	0.4789
Cyprus	0.1654	0.1637	0.1811	0.1682	0.1811	0.1851	0.1830	0.2079	0.1988	0.2206
Latvia	0.3372	0.3183	0.3106	0.3008	0.2960	0.2849	0.2975	0.3377	0.3126	0.3059
Lithuania	0.3462	0.3543	0.3593	0.3521	0.3534	0.3451	0.3522	0.3894	0.3952	0.4059
Hungary	0.2713	0.2775	0.2783	0.2721	0.2643	0.2674	0.3229	0.3338	0.3500	0.3609
Austria	0.1883	0.1855	0.1890	0.1877	0.1740	0.1766	0.1739	0.1819	0.1898	0.1870
Poland	0.1837	0.1861	0.1873	0.1782	0.1766	0.1714	0.1657	0.1623	0.1692	0.1666
Portugal	0.0227	0.0231	0.0215	0.0214	0.0226	0.0225	0.0234	0.0246	0.0259	0.0266
Romania	0.0655	0.0705	0.0661	0.0666	0.0715	0.0710	0.0714	0.0770	0.0921	0.0918
Slovenia	0.2867	0.2778	0.2716	0.2613	0.2572	0.2556	0.2545	0.2708	0.2647	0.2707
Slovakia	0.0530	0.0539	0.0535	0.1216	0.1247	0.1253	0.1209	0.1292	0.1321	0.1371
Finland	0.1189	0.1212	0.1216	0.1221	0.1229	0.1210	0.1205	0.1293	0.1230	0.1338
Sweden	0.1329	0.1348	0.1329	0.1289	0.1309	0.1286	0.1285	0.1379	0.1391	0.1375
United Kingdom	0.1459	0.1450	0.1417	0.1403	0.1403	0.1386	0.1417	0.1510	0.1486	0.1482
Croatia	0.1002	0.1002	0.1002	0.1005	0.1017	0.1033	0.1040	0.1100	0.1182	0.1185

Source: own study based on data from Eurostat, http://epp.eurostat.ec.europa.eu.

The *G* index, apart from the area and population, also takes into account the size of the transported goods.[29] The greatest value of this index can be observed for Lithuania, Latvia and Estonia, which means that these countries can boast the greatest saturation of the road network, against the background of these three above features. Lithuania and Estonia also reported an average annual growth of the *G* index in the analysed period by respectively 1.78% and 0.65%. In case of Latvia the value of the index has been slightly dropping from year to year by an average of 1.08%.

The *Wg* and *G* indexes describe the density of the road network in relation to a specific size, but they do not allow one to assess the level of meeting the transportation needs, because they do not specify whether the length of the roads is sufficient. But they do allow one to make a comparison of the described features in terms of equipment with the road network, and therefore they are part of the transport logistics infrastructure.

[29]Bojar E., The triple helix in regional development – the role of clusters, [in]: Clusters politics management good clustering practices in the world, Ed. Bojar E., TNOiK, Toruń 2009, p. 59.

Summary

The conducted research has indicated a lack of inequality in the equipment with the logistic infrastructure of road freight transport in terms of concentration in the specified European countries in the years 2001-2011. Values of the Herfindahl-Hirschaman Index for the number of providers of transport services also point to a competitive common market for transport services. The analysed countries are also similar in terms of the road network saturation, although one can distinguish here countries in which the length of the roads is greater than the average for all analysed countries, and countries which show a deficiency, compared to the average. Perhaps the results would have been different, if the analysis had covered all European countries, especially those in which the length of roads is significantly higher than in the others, such as Germany, France, Italy, Spain. However a selection of countries for the analysis was dictated by the availability of relevant data. It should be remembered that the level of competition in the market cannot be assessed on the basis of concentration indexes only. Taking into account specific parameters of the goods transport infrastructure, disturbances in the competition can occur even at a low concentration, and they can lead to the dominant role of one entity. One should also take into account the fact that the value of the applied concentration indexes also depends on the number of the entities, even though the Herfindahl-Hirschman Index is much less sensitive to changes in the number of entities, compared to other indexes. In addition, the equipment with transport infrastructure also depends on the legal regulations and economic situation of a given country. Therefore, concentration and saturation indexes should be one of the elements of a comprehensive analysis of the freight logistics infrastructure.

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