The development of collective transport modes share in total inland passenger transport performance of selected European countries from the perspective of sustainable city logistics

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Abstract

Sustainable development of cities is based on three pillars – economic pillar, environmental pillar and social pillar. Emphasis is placed on the environmental pillar from the perspective of city logistics, because the transport is an important producer of emissions and associated negative environmental impacts. An important role in terms of negative environmental impacts is represented by passenger car transport, because passenger car transport produces more emissions per capita than collective transport. Collective transport modes represented by buses, coaches, trolley-buses and trains are more environmentally friendly than using individual passenger car transport. EUROSTAT defined seventeen sustainable development goals and groups of indicators. This article is focused on the indicator "Share of busses and trains in total passenger transport" which measures the share of collective transport modes in total inland passenger transport performance, expressed in passenger-kilometres. The aim of the article is to analyse the development of this indicator of selected European countries between 2007 and 2016 from the perspective of sustainable city logistics.
KEY WORDS: *sustainable development, sustainable development indicators, collective transport modes, sustainable city logistics*

1. Introduction

City logistics is a key catalyst in the urban economy, but in parallel, urban transport significantly affects the quality of life in the urban environment [1, 2]. Gatta et al. [3] stressed two fast-rising trends that make city logistics solutions even more challenging, there are: urbanization and e-commerce. Nathanail, Adamos and Gogas [1] summarized the basic assumptions for dealing with the issue of use of collective transport modes from the perspective of sustainable city logistics, there are: over 50% of the world population is living in cities (see as well as [4]); more than 100 million people have migrated to cities globally since the beginning of this decade [5]; around 75% of the population lives in urban areas in Europe [6]; annually, approximately 1% of Gross Domestic Product is lost by the European economy due to congestion [7] and by 2050, at least 70% of world population will live in cities [5].

The concept of sustainable city logistics is closely related with the concept of sustainable development. Olawumi and Chan [8] stressed the importance of Brundtland Report for the World Commission on Environment and Development in 1992 where the term of "sustainable development" was introduced. Sustainable development is a development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs [9]. The sustainable development is based on a three-pillar concept defined by Elkington [10]. This three-pillar concept is based on the integration the economic, the environmental and the social aspects and impacts into strategic and daily management and decision making processes [10]. Sustainable development is one of the main objectives of the global development strategy through 2030, adopted by the United Nations General Assembly in September 2015 [11].

Cheba and Saniuk [12] emphasize that one of the most important areas of sustainable development is the transport sector. The main trends in sustainable city logistics are according to Kauf [13] cooperation between suppliers, customers and the public administration, development and implementation of new business models enabling to generate benefits not only for operating entities, but also for the city. The transport system in a sustainable society is very important, because it has a direct impact on human health and safety [13].

The share of collective transport modes in terms of city logistics is quite significant. Increased use of collective transport modes, for example trains, motor coaches, buses and trolley buses, in comparison with individual passenger car transport has following advantages: lower emissions per capita; reduction of congestion, noise and vibration; lower energy intensity and greater accessibility to all population groups. The use of collective transport modes has a direct

impact on the quality of the city logistics system. The aim of the article is to analyse the development of the indicator "Share of busses and trains in total passenger transport" of selected European countries between 2007 and 2016 from the perspective of sustainable city logistics.

2. Materials and methods

EUROSTAT [14, 15] defined seventeen groups of sustainable development indicators, there are: Group 1 – No poverty; Group 2 – Zero hunger; Group 3 – Good health and well-being; Group 4 – Quality education; Group 5 – Gender equality; Group 6 – Clean water and sanitation; Group 7 – Affordable and clean energy; Group 8 – Decent work and economic growth; Group 9 – Industry, innovation and infrastructure; Group 10 – Reduced inequalities; Group 11 – Sustainable cities and communities; Group 12 – Responsible consumption and production; Group 13 – Climate action; Group 14 – Life below water; Group 15 – Life on land; Group 16 – Peace, justice and strong institutions and Group 17 – Partnership for the goals. Each group of indicators consists of several sub indicators that are focused on a particular area of sustainable development.

Indicators linked to the sustainable city logistics are located in Group 11 entitled: "Sustainable cities and communities". This group of indicators aims to renew and plan cities and other human settlements in a way that they offer opportunities for all, with access to basic services, energy, housing, transportation, green public spaces, while improving resource use and reducing environmental impacts and envisions cities as environmentally resilient human settlements, which drive sustainable development, stimulate innovation and foster community cohesion and personal safety [16]. This group is further subdivided into eleven sub indicators: Overcrowding rate by poverty status; Population living in households considering that they suffer from noise, by poverty status; Difficulty in accessing public transport by level of difficulty and degree of urbanisation; People killed in road accidents; Exposure to air pollution by particulate matter; Recycling rate of municipal waste; Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor by poverty status; Population connected to at least secondary wastewater treatment; Share of busses and trains in total passenger transport; Artificial land cover and Population reporting occurrence of crime, violence or vandalism in their area by poverty status [16].

This article is focused on the sub indicator named "Share of busses and trains in total passenger transport" which measures the share of collective transport modes in total inland passenger transport performance, expressed in passenger-kilometres (pkm). Collective transport modes refer to buses, including coaches and trolley-buses, and trains. Total inland transport includes transport by passenger cars, buses and coaches, and trains. All data are based on movements within national territories, regardless of the nationality of the vehicle. The data collection methodology is voluntary and not fully harmonised at the EU level. Other collective transport modes, such as tram and metro systems, are also not included due to the lack of harmonised data. For countries, where rail transport statistical legislation does not apply, the totals contain only the share of coaches, buses and trolley buses [17].

The sub indicator "Share of busses and trains in total passenger transport" is composed of two values – x_i ("Share of motor coaches, buses and trolley buses in total inland passenger transport performance") and x_j ("Share of trains in total inland passenger transport performance"). The standard deviation is used for the calculation of the amount of variation or dispersion of a set of data values. Standard deviation σ is usually defined as the square root of the variance $D(X)$ of a random variable X – (Equation 1); standard deviation σ can be also calculated using the mean value $E(X)$ or $E(X^2)$ – (Equation 2, 3) [18]:

$$\sigma = \sqrt{D(X)} \quad (1)$$

$$\sigma = \sqrt{[E(X^2) - (E(X))^2]} \quad (2)$$

$$\sigma = \sqrt{[1/n \, . \, \sum (x_i - (1/n \, . \, \sum x_i))^2]} \quad (3)$$

Average values (Equation 4, 5) of both analysed sub indicators ($\bar{x}_i$ and $\bar{x}_j$) of selected European countries between 2007 and 2016 are compared with the average values of 28 countries of European Union, where $\bar{x}_i$ is the average value of "Share of motor coaches, buses and trolley buses in total passenger transport", $\bar{x}_j$ is the average value of "Share of trains in total passenger transport", n is the number of analysed values and x_{in} and x_{jn} are specific values of both sub indicators:

$$\bar{x}_i = [1/n \, . \, (x_{i1} + x_{i2} + ... + x_{in})] \quad (4)$$

$$\bar{x}_j = [1/n \, . \, (x_{j1} + x_{j2} + ... + x_{jn})] \quad (5)$$

In the following chapter there are summarized and discussed the results from presented research.

3. Results and discussion

The first analysed sub indicator is "Share of motor coaches, buses and trolley buses in total passenger transport". The results are presented in Table 1.

The value of the first sub indicator of 28 countries of European Union decreased by 0.4 percentage point in comparison years 2016 and 2007. Turkey achieved the largest decline of sub indicator value between 2007 and 2016; it was a decrease of 13.9 percentage points. A significant decrease in the sub indicator value between 2007 and 2016

was also in these other countries: Bulgaria (- 7.7 percentage points), North Macedonia (- 7.0 percentage points), Poland (- 6.6 percentage points) and Slovakia (- 6.2 percentage points). France achieved the greatest increase of sub indicator value between 2016 and 2007; it was a growth of 3.3 percentage points. A significant increase in the sub indicator value between 2007 and 2016 was also in these other countries: Ireland (+ 3.0 percentage points), Finland (+ 1.9 percentage point), Romania (+ 1.7 percentage point) and Luxembourg (+ 1.2 percentage point).

Turkey has the highest standard deviation (4.367) between 2007 and 2016. This means that there were the biggest fluctuations during the years 2007-2016 in the analysed sub indicator. On the other side, Iceland (0.000) has the lowest standard deviation value of the analysed sub indicator. This means that Iceland has the most constant values. Turkey reached the highest sub indicator values in all analysed years (2007-2016). Netherlands reached the lowest sub indicator values between 2007 and 2016.

Table 1 Values of the indicator *"Share of motor coaches, buses and trolley buses in total passenger transport"* (% of total inland passenger-km) [authors based on 17]

State	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	σ	$\bar{x}_i$
EU-28	9.8	9.8	9.2	9.4	9.4	9.5	9.8	9.6	9.5	9.4	0.196	9.54
Belgium	14.1	13.0	13.0	12.7	12.8	12.9	11.9	11.4	10.9	10.5	1.056	12.32
Bulgaria	21.8	20.8	16.8	16.4	15.9	14.8	14.0	15.1	14.6	14.1	2.597	16.43
CR	17.0	16.9	16.9	19.5	18.0	17.7	17.9	18.5	17.3	17.1	0.793	17.68
Denmark	10.7	10.5	10.4	10.5	10.1	9.8	9.8	9.7	9.8	9.8	0.359	10.11
Germany	6.5	6.3	6.1	6.0	5.8	5.6	5.7	5.8	6.0	5.8	0.265	5.96
Estonia	20.7	18.5	16.4	16.6	16.3	16.8	17.4	16.5	20.0	17.9	1.489	17.71
Ireland	14.2	14.4	15.0	14.5	19.4	14.4	14.1	17.3	16.7	17.2	1.721	15.72
Greece	18.5	17.9	16.9	17.3	17.6	17.7	17.8	17.7	17.5	17.1	0.424	17.60
Spain	14.0	14.3	13.3	12.3	13.5	13.7	13.2	10.6	11.9	11.8	1.107	12.86
France	5.5	5.7	5.2	5.3	5.4	5.4	8.1	8.1	8.0	8.8	1.408	6.55
Croatia	12.1	12.5	10.7	10.7	10.5	10.7	11.5	11.9	11.0	12.3	0.722	11.39
Italy	12.4	12.4	11.7	12.8	13.2	14.7	14.1	13.7	12.3	12.0	0.923	12.93
Cyprus	19.7	18.8	17.6	18.1	18.3	18.7	18.5	18.2	18.7	18.6	0.521	18.52
Latvia	15.7	16.1	15.1	17.1	18.9	18.3	18.0	17.0	15.8	15.1	1.290	16.71
Lithuania	8.4	8.2	7.1	7.6	8.3	7.3	7.8	10.8	9.9	9.1	1.115	8.45
Luxembourg	11.1	11.4	11.4	12.1	12.5	12.4	12.4	12.2	12.4	12.3	0.489	12.02
Hungary	21.5	22.1	20.7	21.5	21.5	22.3	22.3	22.6	22.3	21.7	0.543	21.85
Malta	19.4	19.2	18.1	18.5	17.6	17.5	17.0	16.9	17.7	17.4	0.817	17.93
Netherlands	2.9	3.0	2.9	2.9	3.0	2.7	2.7	2.7	3.0	3.0	0.125	2.88
Austria	11.1	10.6	10.0	10.6	10.4	10.4	10.3	10.3	10.2	10.2	0.288	10.41
Poland	20.8	19.9	17.9	16.8	15.7	16.0	15.3	15.5	14.7	14.2	2.089	16.68
Portugal	6.5	6.4	6.2	6.5	6.3	6.4	6.6	6.1	6.2	6.7	0.181	6.39
Romania	14.0	20.7	17.3	16.3	16.2	17.2	16.8	16.9	15.5	15.7	1.637	16.66
Slovenia	11.4	10.9	10.7	10.8	11.0	11.1	11.4	11.6	11.8	11.8	0.385	11.25
Slovakia	22.0	20.6	15.8	15.3	15.7	15.6	15.1	15.2	14.8	15.8	2.396	16.59
Finland	10.0	10.1	10.0	9.9	9.8	9.8	9.8	9.8	9.7	11.9	0.618	10.08
Sweden	7.2	7.1	7.1	7.3	7.4	7.3	7.5	7.3	7.3	7.2	0.119	7.27
UK	5.5	5.9	6.0	6.2	5.9	5.8	5.6	5.4	5.4	4.6	0.427	5.63
Iceland	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	0.000	11.40
Norway	6.7	6.7	6.7	6.9	7.0	5.6	5.5	5.4	5.7	5.9	0.609	6.21
Switzerland	5.5	5.2	5.1	5.1	5.7	5.7	5.7	5.8	5.9	5.9	0.301	5.56
N. Maced.	20.1	22.1	21.6	22.9	23.1	21.2	17.8	15.0	14.8	13.1	3.522	19.17
Turkey	42.4	41.3	40.6	38.3	38.4	36.6	34.9	33.5	30.7	28.5	4.367	36.52
Maximum	42.4	41.3	40.6	38.3	38.4	36.6	34.9	33.5	30.7	28.5	4.367	36.52
Minimum	2.9	3.0	2.9	2.9	3.0	2.7	2.7	2.7	3.0	3.0	0.000	2.88
Median	12.4	12.5	11.7	12.3	12.8	12.9	12.4	11.9	11.9	12.0	0.722	12.32
Explanatory notes	σ (standard deviation), $\bar{x}_i$ (arithmetic mean), EU-28 (28 countries of European Union), CR (Czech Republic), N. Maced. (North Macedonia), UK (United Kingdom)											

The average value of the sub indicator ($\bar{x}_i$) of 28 European countries between 2007 and 2016 is 9.54% of total inland passenger-km. These European countries have a lower sub indicator value than the EU-28 average value: Lithuania (8.45%), Sweden (7.27%), France (6.55%), Portugal (6.39%), Norway (6.21%), Germany (5.96%), United Kingdom (5.63%), Switzerland (5.56%) and Netherlands (2.88%). Other European countries have higher value than the EU-28 average value.

The second analysed sub indicator is "Share of trains in total passenger transport". The results are presented in Table 2.

The value of the second sub indicator of 28 countries of European Union increased by 0.6 percentage point in comparison years 2016 and 2007. Romania achieved the largest decline of sub indicator value between 2007 and 2016; it was a decrease of 4.4 percentage points. A significant decrease in the sub indicator value between 2007 and 2016 was also in these other countries: Croatia (- 2.3 percentage points), Bulgaria (- 2.2 percentage points), Hungary (- 1.7 percentage point) and Latvia (- 1.5 percentage point). Slovakia achieved the greatest increase of sub indicator value between 2016 and 2007; it was a growth of 3.4 percentage points. A significant increase in the sub indicator value between 2007 and 2016 was also in these other countries: Switzerland (+ 2.8 percentage points), United Kingdom (+ 2.2 percentage points), Austria (+ 2.1 percentage points) and Czech Republic and Spain (+ 1.6 percentage point).

Romania has the highest standard deviation (1.352) between 2007 and 2016. This means that there were the biggest fluctuations during the years 2007-2016 in the analysed sub indicator. On the other side, Estonia (0.145) has the lowest standard deviation value of the analysed sub indicator. This means that Estonia has the most constant values. Switzerland reached the highest sub indicator values in all analysed years (2007-2016). Lithuania reached the lowest sub indicator values between 2007 and 2016, except 2014 when the lowest sub indicator value has Greece.

Table 2 Values of the indicator *"Share of trains in total passenger transport"* (% of total inland passenger-km) [authors based on 17]

State	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	σ	$\bar{x}_j$
EU-28	7.1	7.4	7.1	7.2	7.4	7.7	7.8	7.8	7.8	7.7	0.279	7.50
Belgium	7.1	7.5	7.5	7.7	7.7	7.8	8.2	8.2	7.8	7.7	0.309	7.72
Bulgaria	4.4	4.0	3.7	3.6	3.5	3.1	2.9	2.6	2.3	2.2	0.696	3.23
CR	7.3	7.1	6.8	7.5	7.6	8.3	8.5	8.4	8.6	8.9	0.687	7.90
Denmark	9.7	9.7	9.5	9.8	10.0	10.2	10.3	9.7	9.3	8.6	0.460	9.68
Germany	7.8	8.1	7.9	8.0	8.5	8.9	8.4	8.5	8.4	8.6	0.330	8.31
Estonia	2.1	2.1	1.9	2.0	1.9	1.8	1.6	1.9	1.8	2.0	0.145	1.91
Ireland	3.4	3.3	2.8	2.9	3.8	2.8	2.7	2.9	3.0	2.9	0.326	3.05
Greece	1.6	1.3	1.2	1.1	0.8	0.7	0.9	0.9	1.0	1.0	0.250	1.05
Spain	5.0	5.5	5.4	5.4	5.6	5.6	6.1	6.7	6.7	6.6	0.587	5.86
France	9.6	10.1	9.4	9.3	9.3	9.5	10.5	10.3	10.3	9.7	0.434	9.80
Croatia	5.0	5.4	5.6	5.6	4.9	3.5	3.1	3.0	3.1	2.7	1.144	4.19
Italy	6.0	6.0	5.5	5.5	5.7	6.4	6.3	6.2	6.3	6.1	0.313	6.00
Cyprus	:	:	:	:	:	:	:	:	:	:	x	x
Latvia	4.9	5.2	4.7	4.7	4.9	4.8	4.7	4.0	3.5	3.4	0.590	4.48
Lithuania	0.6	0.6	0.6	0.7	0.8	0.7	0.8	1.0	0.9	1.0	0.149	0.77
Luxembourg	4.1	4.3	4.3	4.5	4.4	4.6	4.8	4.3	4.7	4.6	0.206	4.46
Hungary	11.0	10.4	10.2	10.0	10.2	10.1	10.2	9.9	9.5	9.3	0.445	10.08
Malta	:	:	:	:	:	:	:	:	:	:	x	x
Netherlands	9.6	9.8	9.8	10.2	10.5	10.7	11.3	11.8	10.8	11.0	0.676	10.55
Austria	10.0	11.1	11.1	11.0	11.3	11.8	12.2	12.1	12.0	12.1	0.663	11.47
Poland	8.5	8.2	7.4	7.1	6.9	7.2	6.7	6.3	6.8	7.3	0.636	7.24
Portugal	4.1	4.3	4.4	4.4	4.5	4.1	4.0	4.1	4.2	4.2	0.155	4.23
Romania	8.6	7.1	6.2	5.6	5.3	4.6	4.3	4.6	4.6	4.2	1.352	5.51
Slovenia	2.6	2.7	2.6	2.5	2.3	2.3	2.3	2.1	2.1	2.0	0.229	2.35
Slovakia	6.0	6.4	6.6	6.7	7.0	7.1	7.1	7.3	9.4	9.4	1.111	7.30
Finland	5.0	5.4	5.1	5.2	5.0	5.3	5.3	5.0	5.3	5.6	0.189	5.22
Sweden	7.9	8.6	8.7	8.7	8.7	9.1	9.1	9.2	9.5	9.3	0.435	8.88
UK	6.6	6.9	6.9	7.5	7.8	8.1	8.3	8.5	8.7	8.8	0.761	7.81
Iceland	:	:	:	:	:	:	:	:	:	:	x	x
Norway	4.6	4.8	4.7	4.8	4.5	4.6	4.8	4.9	4.9	5.1	0.168	4.77
Switzerland	17.0	17.1	17.4	17.6	19.6	19.2	19.3	19.6	19.8	19.8	1.139	18.64
N. Maced.	2.1	2.6	2.8	2.5	2.0	1.5	1.0	1.0	2.1	1.0	0.658	1.86
Turkey	2.7	2.4	2.5	2.4	2.4	1.7	1.4	1.6	1.6	1.4	0.485	2.01
Maximum	17.0	17.1	17.4	17.6	19.6	19.2	19.3	19.6	19.8	19.8	1.352	18.64
Minimum	0.6	0.6	0.6	0.7	0.8	0.7	0.8	0.9	0.9	1.0	0.145	0.77
Median	5.5	5.8	5.6	5.6	5.5	5.5	5.7	5.6	5.8	5.9	0.452	5.69
Explanatory notes	σ (standard deviation), $\bar{x}_j$ (arithmetic mean), EU-28 (28 countries of European Union), CR (Czech Republic), N. Maced. (North Macedonia), UK (United Kingdom), : (not available), x (not calculated)											

The average value of the sub indicator ($\bar{x}_j$) of 28 European countries between 2007 and 2016 is 7.50% of total inland passenger-km. These European countries have a higher sub indicator value than the EU-28 average

value: Belgium (7.72%), United Kingdom (7.81%), Czech Republic (7.90%), Germany (8.31%), Sweden (8.88%), Denmark (9.68%), France (9.80%), Hungary (10.08%), Netherlands (10.55%), Austria (11.47%) and Switzerland (18.64%). Other European countries have lower value than the EU-28 average value.

In the Figure 1 are presented average values (between 2007 and 2016) of analysed sub indicators only for countries with both available values. The Figure 1 also indicates the average values of both sub indicators for 28 countries of European Union.

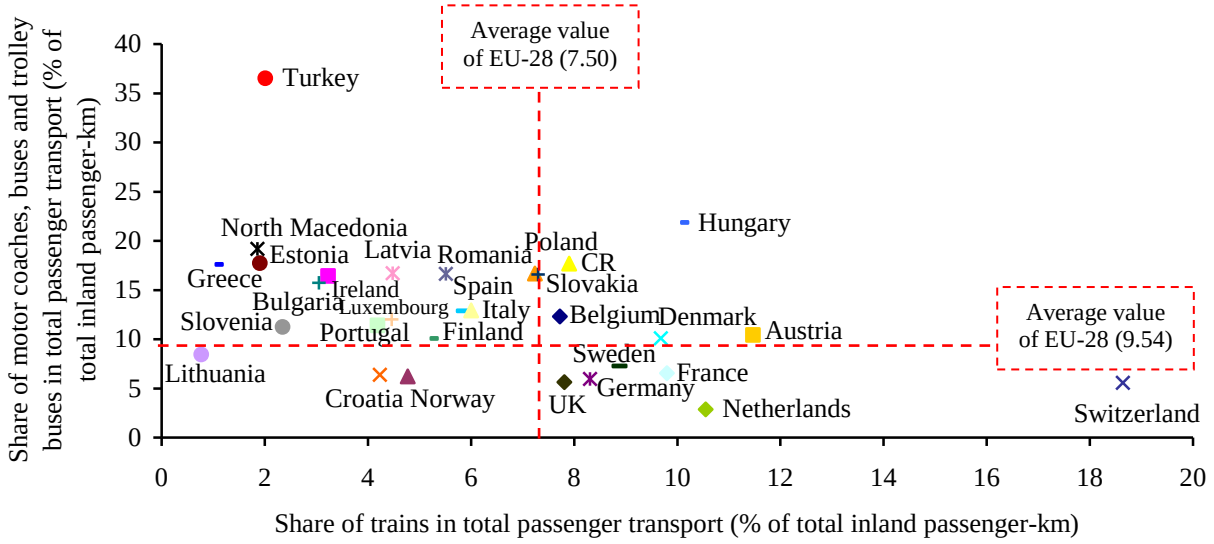

Fig. 1 Comparison of average sub indicators values between 2007 and 2016 [authors based on 17]

Five countries have higher values than the average values for 28 countries of European Union for both sub indicators there are: Hungary ($\bar{x}_i$ = 21.85%, $\bar{x}_j$ = 10.08%), Austria ($\bar{x}_i$ = 10.41%, $\bar{x}_j$ = 11.47%), Denmark ($\bar{x}_i$ = 10.11%, $\bar{x}_j$ = 9.68%), Czech Republic ($\bar{x}_i$ = 17.68%, $\bar{x}_j$ = 7.90%) and Belgium ($\bar{x}_i$ = 12.32%, $\bar{x}_j$ = 7.72%). Only three countries have lower values than the average values for 28 countries of European Union for both sub indicators there are: Lithuania ($\bar{x}_i$ = 8.45%, $\bar{x}_j$ = 0.77%), Croatia ($\bar{x}_i$ = 11.39%, $\bar{x}_j$ = 4.19%) and Norway ($\bar{x}_i$ = 6.21%, $\bar{x}_j$ = 4.77%). Lithuania, Croatia and Norway have a lower rail network length. Lithuania has a rail network length about 1 911 km, Croatia has 2 605 km and Norway has 4 134 km of rail network length [19]. For example, Czech Republic has the length of a railway network compared to these countries about 9 408 km and Hungary about 7 246 km [19].

In the Figure 2 are presented average values of indicator "Share of busses and trains in total passenger transport" between 2007 and 2016 for countries with values less than 15% and higher than 20%; other countries have reached values close to the average value of the indicator.

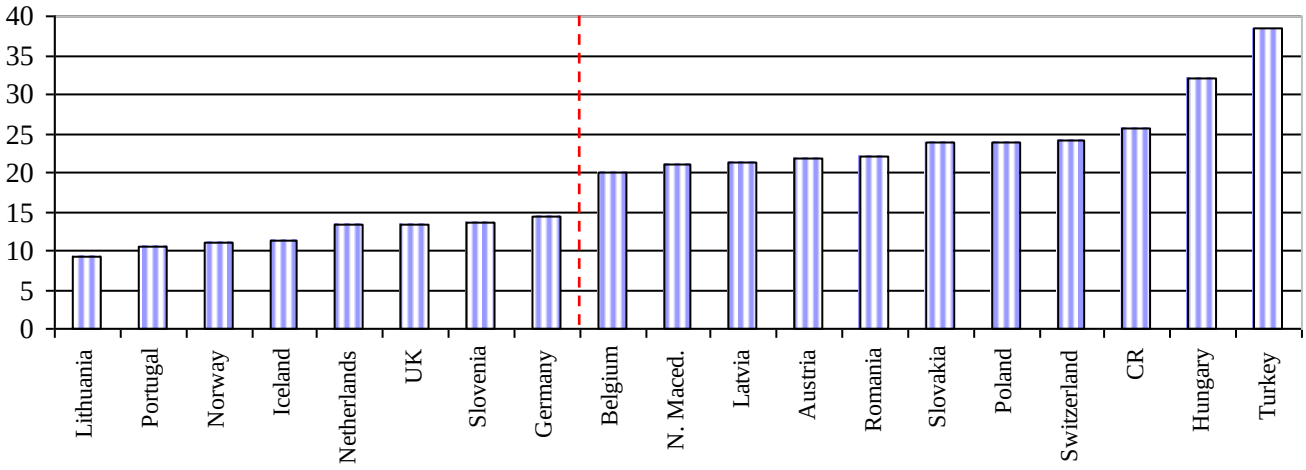

Fig. 2 Comparison of average indicators values ("Share of busses and trains in total passenger transport") between 2007 and 2016 for countries with values less than 15% and higher than 20% [authors based on 17]

Collective transport modes are widely used in Turkey, Hungary and the Czech Republic in comparison with individual passenger cars transport mode. The average value of analysed indicator is greater than 25% between 2007 and 2016 in Turkey (38.53%), Hungary (31.93%) and the Czech Republic (25.58%). On the other hand, there are many countries where the average value of the monitored indicator is less than 15%: Germany (14.27%), Slovenia (13.60%),

United Kingdom (13.44%), Netherlands (13.43%), Iceland (11.40%), Norway (10.98%), Portugal (10.62%) and Lithuania (9.22%). Conversely, passenger cars transport is widely used in these countries.

4. Conclusions

The issue of the collective transport modes share in total inland passenger transport performance from the perspective of sustainable city logistics is very current, because individual passenger cars transport causes more negative environmental impacts per transported passenger compared with the collective transport modes. The aim of the article was to analyse the development of the indicator of selected European countries between 2007 and 2016 from the perspective of sustainable city logistics. This article was focused on the sub indicator named "Share of busses and trains in total passenger transport" which consists of two sub indicators – "Share of motor coaches, buses and trolley buses in total inland passenger transport performance" and "Share of trains in total inland passenger transport performance".

The analysis showed that some countries use collective transport modes from 25% or more in the total inland passenger transport performance (Turkey, Hungary and the Czech Republic). On the other hand, Lithuania uses collective transport modes from less than 10% in the total inland passenger transport performance. However, this may be due to the quality and range of the rail and road transport network, the frequency of connections, fare prices, the quality of service provided and the quality of life in the country.

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