DEVELOPMENT OF PUBLIC TRANSPORT IN THE CITY – A CHALLENGE FOR URBAN LOGISTICS IN TERMS OF SUSTAINABLE DEVELOPMENT

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Abstract

Economic progress results in a dynamic development of cities. The high tempo of urbanization is becoming one of the major challenges nowadays and calls for adequate planning solutions to the development of cities, and for new management systems which can form communities economically, socially and ecologically sustainable.

Urban logistics deals with the flow of materials, people and information within a city, and transport is one of its elements. It provides transport accessibility and organizes both freight and passenger transport. Considering the urban functions and the environmental impact of urban transport, it is important to organize it with the economic, social and environmental aspect of sustainable development in mind. The aim of this article is to point out to the problems of urban logistics connected with the organization of urban transport in terms of sustainable development, and to present a quantitative data analysis concerning Polish urban transport in 2012.

Key words: sustainable development, urban logistics, urban transport, sustainable transport.

Introduction

Transport influences the activities of all businesses as well as individual persons. The effectiveness of the system, therefore, depends on the efficiency of transport processes. Mobility of people is vital to the economic and social development of urban areas. Unfortunately, the advances of passenger transport can compromise the quality of life in those areas and have detrimental effects on the environment. That is why it is important to devise such solutions ensuring transport availability which can support the existence of both present and future generations. In this context we talk about sustainable transport. Its premises can be realized through urban logistics. The general goal of logistics includes:

- economic goal: ensuring the development of cities through stimulating business activities in urban areas,
- social goal: ensuring the desired quality of life in urban areas,
- ecological goal: considering the ecological requirements in the realization of the economic and social goals.

In other words, the goal of logistics is to coordinate the flow of all kinds of goods between businesses and institutions so that the quality of life and economy increase at the lowest cost possible and with the smallest environmental impact. That is why urban logistics should organize urban transport whose effectiveness depends on the level of its integration. The integration of urban transport is understood as an organizational process supporting the close and effective cooperation of transport agents in order to improve the quality of their services (Dydkowski, 2009). The level of urban transport integration is determined by the availability of different means of transport. It is legitimate, therefore, to analyze the data characterizing the functioning of urban transport in the aspect of sustainable development and urban logistics.

1. Basic premises of the sustainable transport concept

Transport has become essential to the life of societies and the economy. The downside is that it is responsible for global climate change through the green-house gases emission. 95% of energy in transport is produced from liquid fuels, which means that without proper political and technological changes in transport systems, the level of air pollution emission will rise as they develop (Grant-Muller, Usher, 2014: 149). The negative effects of transport processes on people and ecosystems create the need for new organizational solutions utilizing the sustainable development principle. Paraphrasing the definition of sustainable development adopted by the Brundtland Commission, sustainable transport is defined as the system which:

1. "Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;
2. Is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development;

3. Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise" (Hyard, 2013: 1376).

Most of research published in the subject literature of transport and sustainable transport, relates to the problem of the energy consumption and carbon dioxide emission (Gujba et al. 2013: 354). This only confirms the significance of the climate change issue which requires a global approach (Zawada, 2007: 78). The level of carbon dioxide emissions in passenger transport stems from seven factors: population, gross domestic product at constant prices, the number of passengers carried, the quantity and type of used fuel, income, willingness to travel, tourist activity, primary energy, carbon dioxide emission in different transport branches (Loo, Li, 2012: 467). The relationship between the overall level of carbon dioxide emitted by passenger transport and the mentioned factors can be expresses by a formula resulting from applying the multiplicative Logarithmic Mean Divisia Index (*LMDI*) decomposition technique (Loo, Li, 2012: 467):

$$G = \sum_{i,j} P \times \frac{E}{P} \times \frac{T}{E} \times \frac{T_i}{T} \times \frac{F_i}{T_i} \times \frac{F_{i,j}}{F_i} \times \frac{G_{i,j}}{F_{i,j}} = \sum_{i,j} P \times I \times TP \times TM_i \times ME_i \times FM_{i,j} \times EF_{i,j},$$

where:
i – the passenger transport mode,
j – the fuel type,
G – andamountofCO2 emission,
P – national population,
E – national GDP at constant price,
T – passenger turnover volume,
F – amount of fuel consumption,
I – income factor,
TP – travel propensity factor,
TM – travel activity mix factor,
ME – modal energy factor,
FM – fuel mix factor,
EF – emission factor.

The level of carbon dioxide is influenced by four groups of factors:
1. socio-economic – encompassing economic and demographic measures,
2. processes related – measuring the effects of carbon dioxide reduction activities,

3. fuel related - connected with the given type of fuel,
4. demand related – connected with the demand for passenger transport.

Controlling the mentioned factors by the means of legislature and different kinds of activities connected with passenger transport is reflected in lower levels of carbon dioxide emissions in this sector. The average level of carbon dioxide emitted by new cars per kilometer in the years 2007-2012 was decreasing by around 3,588% in the European Union and by 1,585% in Poland. The emission per kilometer in the years 2007 and 2008 was bigger in the European Union than in Poland which changed in 2009. Altogether, the average annual decrease of carbon dioxide emission per kilometer by new cars in the European Union in the analyzed period was two times bigger than in Poland. In 2012 Poland, ranked 7th, was among UE countries with the highest carbon dioxide emission per kilometer from passenger cars. The average level of carbon dioxide emission per kilometer from passenger cars was higher by 7,34% than the UE level. And compared to Denmark, where the carbon dioxide emission per kilometer was the lowest, the emission level in Poland was 21,28% higher. Carbon dioxide emission in passenger transport is still a problem in many countries and it calls for system solutions minimizing its impact on the environment. And urban logistics is where they can be found.

2. Urban transport as an element of urban logistics in the context of sustainable development

The level of sustainability of cities is an important element of their development. The implementation of sustainable development concept in cities is seen as a way to improve the state of the environment, and, consequently, the quality of life (Jim, 2013: 742). Sustainable development of cities is not clearly defined in the literature. It can be described as an economic, social and environmental organization of urban life, catering to the needs of present and future generations and preserving the environment and its ecosystems (Vojnovic, Darden, 2013: 90). The sustainability of a city can be understood as an effective use of resources to improve the quality of life with the consideration of limited environmental possibilities (Shen et al. 2012: 33).

It is a challenge for many cities to make their transport systems sustainable which is linked with the number of cars used by citizens (Rose 2012: 81). Because urban logistics deals with problems concerning the flow of goods, people and information within the city, its responsibility is to organize urban transport. Urban logistics brings technologies and tools for tackling the urban dilemma: increasing the access to city centres through the development of transport and other integral functions on one hand, and decreasing traffic which compromises the quality of life on the other (Fijałkowski, 2009: 270).

The increasing number of cars seems to be the biggest challenge for cities. In order to reduce it, various activities are realized. They can be divided into hard and soft measures. Hard measures include: road tolls, congestion charges, higher fuel prices. Research shows that such measures do not bring desired effects and do not refrain people from using private cars (Friman et al.2013: 110). They are also frowned upon by the society and for these reasons the soft measures are favoured, which were presented in table 1.

Table 1. Different types of soft policy measures

Types of measures	Aim
Travel policy at workplace	Promotes car-pooling between employees
Travel policy at school	Choosing other alternatives for school runs
Personalized travel planning	Personalized travel information
Information and marketing	Increased knowledge via advertising campaigns and simplified ticket availability
Campaigns for alternative transport modes	Increasing understanding of problems with certain transport choices
Car clubs	Offering cars that are paid for upon actual use
Car cooperatives	Reducing the number of car trips through joint ownership
Tele-working	Reducing the number of trips by, e.g., offering Internet access
Tele-conferencing	Reducing the number of work trips via phone meetings
Shopping from home	Reducing the number of purchasing trips via home deliveries

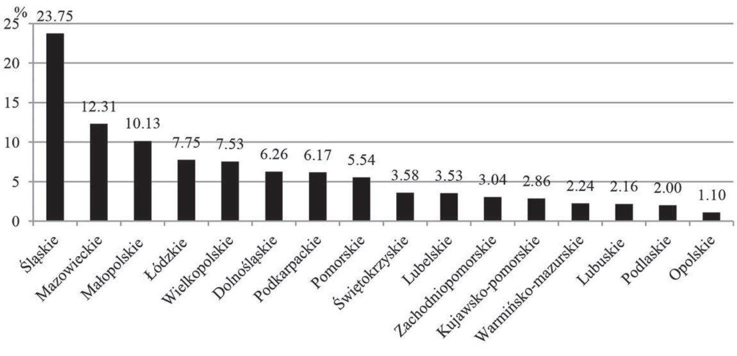
Source: Friman et al. 2013: 110.

In the framework of urban logistics, the goal of the development of passenger transport infrastructure, including urban transport, is to: decrease congestion in cities, shorten journey times and reduce costs, increase the availability of transport, decrease the number of journeys, minimize the pollution emission.

3. The analysis of the structure, dynamics and use of the selected elements of urban transport in Poland

The goal of the analysis is to present the structure and dynamics of the selected elements of urban transport infrastructure in individual voivodeships in Poland. The analysis looks at the following variables: the length of transport routes and the inventory of transport vehicles. It also considers values which are important measures of changes in the transport infrastructure connected especially with the use and exploitation of transport vehicles, vehicles capacity and the number of carried passengers, the workload of vehicles. The analysis compares two years: 2004 (base year) and the year 2012. Figure 1 presents indexes for the lengths of transport routes in Polish voivodeships in 2012.

Figure 1. Indexes for the lengths of transport routes in Polish voivodeships in 2012



The longest transport routes are found in śląskie voivodeship (Figure 3). They constitute 23,75% of total Polish transport routes length. Transport routes in mazowieckie and małopolskie voivodeships make respectively 12,31% and 10,13% of Polish transport routes. Voivodships with the shortest transport routes, which constitute not more than 5% of all routes in the country, are: świętokrzyskie, lubelskie, zachodnipomorskie, kujawsko-pomorskie, warmińsko-mazurskie, lubuskie, podlaskie and opolskie. It is clear that śląskie voivodship leads in terms of the transport routes length which is due to a conurbation there comprised of several cities, each with different functions. The conurbation thrives thanks to a well developed transport system connecting individual cities.

The analysis also concentrates on the condition, use and exploitation of urban transport vehicles, and its results were presented in tables 3 and 4.

Table 3. Measure the dynamics* of inventory, use and operating of urban buses stock in Poland and in voivodships in 2012 (%)

Voivodeships	Inventory number of stock as of 31 December		Share of vehicles in traffic in % of vehicles in the inventory		Total distance travelled by vehicles, thousand vehiclekilometres		Average distance travelled by 1 vehicle during one year (km)		Average distance travelled by 1 vehicle during one day (km)	
	Index 2004=100%	Average rate of change	Index 2004=100%	Average rate of change	Index 2004=100%	Average rate of change	Index 2004=100%	Average rate of change	Index 2004=100%	Average rate of change

Polska	106,46	0,79	103,85	0,47	101,33	0,16	92,35	-0,99	92,20	-1,01
Dolnośląskie	90,36	-1,26	105,13	0,63	89,22	-1,42	93,02	-0,90	93,03	-0,90
Kujawsko -pomorskie	86,73	-1,76	98,77	-0,16	77,11	-3,20	91,74	-1,07	91,88	-1,05
Lubelskie	44,93	-9,52	98,67	-0,17	91,65	-1,08	78,45	-2,99	78,28	-3,01
Lubuskie	96,63	-0,43	101,20	0,15	87,07	-1,72	89,49	-1,38	89,55	-1,37
Łódzkie	96,64	-0,43	101,32	0,16	56,36	-6,92	57,67	-6,65	57,77	-6,63
Małopolskie	105,17	0,63	95,12	-0,62	95,90	-0,52	96,42	-0,46	96,30	-0,47
Mazowieckie	139,38	4,24	110,53	1,26	148,83	5,10	97,06	-0,37	97,16	-0,36
Opolskie	86,67	-1,77	96,10	-0,50	81,87	-2,47	98,24	-0,22	97,84	-0,27
Podkarpackie	89,25	-1,41	98,67	-0,17	75,99	-3,37	86,47	-1,80	86,67	-1,77
Podlaskie	84,49	-2,08	111,69	1,39	89,88	-1,32	94,45	-0,71	94,51	-0,70
Pomorskie	100,31	0,04	93,98	-0,77	89,70	-1,35	100,61	0,08	95,35	-0,59
Śląskie	112,25	1,45	105,06	0,62	121,81	2,50	104,00	0,49	103,96	0,49
Świętokrzy-skie	106,39	0,78	89,02	-1,44	111,52	1,37	118,90	2,19	118,92	2,19
Warmińsko -mazurskie	97,13	-0,36	105,13	0,63	91,53	-1,10	90,06	-1,30	89,94	-1,32
Wielkopol-skie	89,73	-1,34	9,57	-25,42	84,03	-2,15	86,75	-1,76	86,67	-1,77
Zachodnio-pomorskie	95,40	-0,59	17,72	-19,45	95,97	-0,51	97,33	-0,34	97,62	-0,30

* The average rate of change was calculated for period 2004-2012
Source: own calculation based on Transport… (2004 and 2012)

In most cities the inventory of buses was smaller in the year 2012 compared to 2004. The opposite was seen in just a few voivodeships: mazowieckie, śląskie, świętokrzyskie, małopolskie, pomorskie. The biggest increase of the number of buses (39,38% in comparison to the base year) took place in mazowieckie voivodeship. The analysis of the dynamics for the buses actually in use to buses in the inventory showed a decrease of the variable in the year 2012 in comparison to the base year in half of the voivodehips. The biggest decrease was observed in świętokrzyskie voivodeship where the use of bus vehicles dropped by 10,98%. The mileage total of buses in 2012 went up only in some voivodeships (mazowieckie, śląskie, pomorskie). The average mileage of a bus per day was higher in świętokrzyskie, ślaskie and pomorskie voivodeships, whereas the average mileage of a bus per year increased in świętokrzyskie and śląskie voivodeships. In Poland, in comparison to the base year, the following values went up: the inventory of buses, the number of buses in service to the number of buses in the inventory, and the total mileage of buses. However the mileage per bus per day and per year both went down. The tendencies of the variables are confirmed by the average pace of change.

Table 4. Measure the dynamics* of inventory, use and operating of urban trams stock in Poland and in voivodships in 2012 (%)

Viovode-ships	Inventory number of stock as of 31 December		Share of vehicles in traffic in % of vehicles in the inventory		Total distance travelled by vehicles, thousand vehiclekilometres		Average distance travelled by 1 vehicle during one year (km)		Average distance travelled by 1 vehicle during one day (km)	
	Index 2004= 100%	Average rate of change	Index 2004= 100%	Average rate of change	Index 2004= 100%	Average rate of change	Index 2004= 100%	Average rate of change	Index 2004= 100%	Average rate of change
Polska	93,08	-0,89	98,67	-0,17	90,73	-1,21	97,74	-0,28	97,94	-0,26
Dolnośląskie	93,30	-0,86	102,53	0,31	95,72	-0,54	100,01	0,00	100,00	0,00
Kujawsko-pomorskie	103,57	0,44	100,00	0,00	93,43	-0,85	89,73	-1,35	89,69	-1,35
Lubelskie	90,14	-1,29	127,27	3,06	98,82	-0,15	43,81	-9,80	85,71	-1,91
Lubuskie	83,33	-2,25	65,38	-5,17	64,54	-5,33	118,33	2,13	118,32	2,13
Łódzkie	95,50	-0,57	93,90	-0,78	86,33	-1,82	96,40	-0,46	96,35	-0,46
Małopolskie	100,48	0,06	93,75	-0,80	96,39	-0,46	101,91	0,24	102,07	0,26
Mazowieckie	88,71	-1,49	107,89	0,95	86,13	-1,85	89,70	-1,35	89,80	-1,34
Opolskie	-	-	-	-	-	-	-	-	-	-
Podkarpackie	-	-	-	-	-	-	-	-	-	-
Podlaskie	-	-	-	-	-	-	-	-	-	-
Pomorskie	68,69	-4,59	122,78	2,60	115,55	1,82	137,53	4,06	137,31	4,04
Śląskie	90,51	-1,24	100,00	0,00	91,47	-1,11	100,88	0,11	100,93	0,12
Świętokrzyskie	-	-	-	-	-	-	-	-	-	-
Warmińsko-mazurskie	86,84	-1,75	80,00	-2,75	70,82	-4,22	100,33	0,04	100,00	0,00
Wielkopolskie	99,69	-0,04	87,01	-1,72	77,67	-3,11	88,87	-1,46	89,00	-1,45
Zachodnio-pomorskie	103,35	0,41	98,57	-0,18	99,19	-0,10	98,52	-0,19	98,84	-0,15

*The average rate of change was calculated for period 2004-2012

Source: own calculation based on Transport… (2004 and 2012)

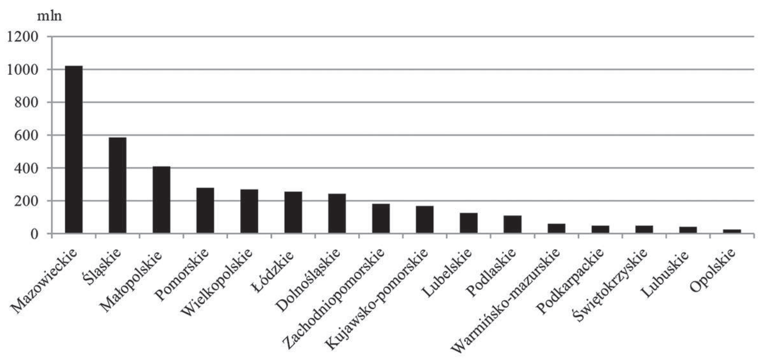
The following changes are observed in the year 2012 in comparison to 2004 in terms of the condition, use and exploitation of trams:

– decrease of the level of all variables for Poland

– slight increase of the number of trams in the following voivodeships: kujawsko-pomorskie, zachodniopomorskie and małopolskie,
– increased use of tram vehicles in the following voivodeships: lubelskie (27,27%), pomorskie (22,78%), mazowieckie (7,89%), dolnośląskie (2,53%), and no change in this respect in the voivodships: kujawsko-pomorskie and sląskie,
– increase of the total mileage of vehicles in pomorskie voivodeship (by 15,55%),
– substantial increase of the average mileage of a vehicle per one day and per one year in pomorskie voivodeship, by respectively 37,53% and 37,31%, and in lubuskie voivodship by respectively 18,33% and 18,32%,
– slight increase of the average mileage of a vehicle per one day and per one year in mołopolskie, śląskie and warmińsko-mazurskie voivodeships.

The results of the vehicles capacity and the carriage of passengers analysis are shown in figure 2 and in tables 5 and 6.

Figure 2. Transport of passengers of urban transport in Polish voivodeships in 2012



The biggest numbers of passengers are carried by urban transport in mazowieckie, śląskie and małopolskie voivodeships. And the number of passengers carried in mazowieckie voivodship in 2012 was higher than the number in śląskie voivodeship by 42,66%, and higher than in małopolskie voivodeship by 60%. The smallest numbers of passengers in 2012 were carried in lubuskie and opolskie voivodeships which are also characterized by the poorest condition of urban transport systems in comparison to other voivodeships in Poland.

Table 5. Dynamics* of stock capacity and transport of passengers by urban transport in 2012 (%)

Viovodeships	Seats in vehicles (thousand)**		Seats in buses (thousand)**		Seats in trams (thousand)**		Transport of passengers (million)**	
	Index 2004 =100%	Average rate of change	Index 2004= 100%	Average rate of change	Index 2004= 100%	Average rate of change	Index 2004= 100%	Average rate of change
Polska	103,29	0,00	103,69	0,00	102,67	0,00	93,19	-0,01
Dolnośląskie	91,89	-0,01	89,32	-0,01	96,25	0,00	79,08	-0,03
Kujawsko-pomorskie	91,86	-0,01	86,97	-0,02	104,07	0,00	75,88	-0,03
Lubelskie	116,41	0,02	122,02	0,03	-	-	128,67	0,03
Lubuskie	84,96	-0,02	85,92	-0,02	81,67	-0,02	73,75	-0,04
Łódzkie	90,95	-0,01	89,48	-0,01	93,31	-0,01	118,79	0,02
Małopolskie	102,95	0,00	96,47	0,00	113,98	0,02	79,61	-0,03
Mazowieckie	115,85	0,02	121,94	0,03	100,64	0,00	115,39	0,02
Opolskie	85,00	-0,02	85,00	-0,02	-	-	82,26	-0,02
Podkarpackie	81,91	-0,02	81,91	-0,02	-	-	61,79	-0,06
Podlaskie	86,68	-0,02	86,68	-0,02	-	-	84,05	-0,02
Pomorskie	99,25	0,00	104,68	0,01	85,87	-0,02	86,95	-0,02
Śląskie	112,32	0,01	117,77	0,02	93,83	-0,01	88,19	-0,02
Świętokrzyskie	99,42	0,00	99,42	0,00	-	-	87,09	-0,02
Warmińsko-mazurskie	97,82	0,00	99,04	0,00	90,74	-0,01	79,33	-0,03
Wielkopolskie	108,97	0,01	93,08	-0,01	137,55	0,04	91,64	-0,01
Zachodniopomorskie	95,83	-0,01	94,36	-0,01	98,59	0,00	87,02	-0,02

* The average rate of change was calculated for period 2004-2012

** as of 31 December

Source: own calculation based on Transport… (2004 and 2012)

Unfortunately, the dynamics of the transport vehicles capacity and the carriage of passengers in the years 2004-2012 shows a downward trend. Only some voivodeships saw an increase:

- lubuskie – increase of the total number of seats in vehicles and in buses, increase in the carriage of passengers,
- łodzkie – increase in the carriage of passengers,
- małopolskie - increase of the total number of seats in vehicles and trams, increase in the carriage of passengers,
- mazowieckie – increase in the total number of seats in vehicles, trams and buses, increase in the carriage of passengers,
- śląskie – increase of the total number of seats in vehicles and in buses,

– wielkopolskie – increase of the total number of seats in vehicles and in trams.

Table 6. Dynamics of network, rolling stock and transport of passengers by metro in 2012 (%)

Specification	Index 2004 =100%	Average rate of change*
Lines (kilometers)	146,50	4,89
Stock – cars	153,85	5,53
Seats in cars	210,76	9,77
Vehicle- kilometres (thousand)	185,09	8,00
Transport of passengers during a year (million)	163,78	6,36
Transport of passengers during a day (million)	163,64	6,35

* The average rate of change was calculated for period 2004-2012
Source: own calculation based on Transport… (2012)

Although Warsaw is the only city in Poland with an underground line, this means of transport has been developing since 2004 in terms of: the length of the line, vehicles inventory, seats in carriages, workload of vehicles, number of passengers. The biggest relative increase and the fastest average tempo of change in 2012 compared to 2004 were connected with the number of seats available in carriages - with respect to the base year, it increased by as much as 110,76%, and grew by approximately 9,77% per year during the period between 2004 and 2012. A significant increase was also observed in the workload of vehicles expressed through kilometers per carriage and its value was 85,09% higher in 2012 compared to the base year, with an average annual increase of 8% during the analyzed period. There was also an increase in a number of other criteria in 2012 in comparison to 2004:

– the length of the underground line increased by 46.50% (annual average increase of 4.89%),
– the number of carriages increased by 53,85% (annual average increase of 5,53%),
– the number of passengers carried per year and per day increased respectively by 63,78% and 63,64% (annual average tempo of change on the level of 6,36% and 6,35% respectively).

Conclusions

Urbanization is connected with the development of urban passenger transport. Urban transport processes realized in cities have negative results on the environment: air and water pollution, noise, limiting green areas.

This translates into the deterioration of citizens' leisure and work, living conditions, road safety and the global climate. That is why it is necessary to implement urban transport management systems which live up to social, ecological and economic needs. Urban logistics is a tool for the implementation of solutions compatible with the premises of sustainable development. It organizes urban transport in such a way that the quality of passenger service and effectiveness are assured with the simultaneous minimization of the environmental impact. A good method to realize this goal seems to be the reduction of the number of cars by promoting public means of transport. Unfortunately, research concerning the tempo of change of the selected elements of infrastructure and the use of urban transport in the period of 2004-2012 shows little development in this respects. Polish vovivodeships where both the transport infrastructure and the way it is managed are on the best level are: śląskie, mazowieckie and małopolskie. However, in the analyzed period we cannot see any major changes in these voivodeships as far as the development of transport is concerned. The increase in the infrastructure is mainly connected with the bus inventory, but it happened in few voivodeships and was not big. The most visible change took place in the underground transport, and was connected with the length of the route, the vehicles inventory and the number of passengers. However, this means of transport is only available in Warsaw. Urban transport, apart from providing mobility for people, contributes to the economic development of regions, and, consequently, the whole country. Moreover, using urban transport has a positive effect on the local lifestyle through the reduction of pollution, noise, congestion, and improved safety. That is why it so important to continue the search for effective solutions attracting city dwellers to urban transport.

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