




Analysis of Bus Transportation Mode in Central Europe

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Abstract: Buses belong to the most important means of public transportation that significantly impact the economic and environmental aspects of people in different countries. This study has focused on studying the relationship between buses and their effect on GDP, road networks and population in Hungary, Poland, Czech and Slovakia. We evaluated the number of buses and the GDP per capita for each country for different years and examined the changes over time and the effect of increasing GDP per capita on the number of buses for these countries. We evaluated the transportation system for each country in terms of the number of buses, the area of the country, the paved road network, and the number of inhabitants with income levels there. Poland excels in the number of buses compared to its vast area and high population, but it is lagging in GDP per capita. Slovakia is the smallest in terms of its population and area but has the highest GDP per capita. The Czech Republic is the best in caring for the road network, constantly updating it, and adding newly paved roads and expressway sectors.

Keywords

Buses, GDP, Population, Area, Paved Road.

1. Introduction:

Public transportation, especially buses (fuel or electric), is one of the leading mobility modes in the world due to the services it provides that are commensurate with the population's economic situation and the world's trends towards sustainability and reducing pollution and congestion. The level of service provided by buses and the amount of demand for them is directly related to several influencing factors, including the income level of the individual and the countries' policies in developing buses in line with the requirements of the population and the changes that occur to it, since the relationship is inverse between the income level of the individual and the demand for using buses for transportation (Egercioğlu & Doğan, 2016). Therefore, there must be a direct interest in developing the bus transportation system commensurate with the country's area, the number of residents and their welfare. As a result, transportation and mobility play a crucial part in urban economics and quality of life (Nanaki et al., 2017).

One of the main tasks of public passenger transport is to satisfy the transport requirements of the area served. The importance of proper coordination of public passenger transport is particularly evident in the development of cities and suburban areas and in the effort to reduce environmental pollution. Transport must meet the transport requirements of society, but it must also contribute to its economic development and to raising the living standards of the population (Konečný et al., 2021)

In most countries, the government is involved in supplying public transportation services. In most cases, it provides substantial subsidies for the operation of the services to increase the equality of accessibility and financial efficiency of the system (Pucher and Renne, 2013). In recent decades, numerous countries have introduced reforms in their public bus services. This has been based mainly on budgetary considerations against the background of inefficient spending by bus companies, and a decline in revenue, due to a steady decrease in the number of passengers (Ida and Talit, 2018).

So, for Central European countries like Hungary, Poland, Czech and Slovakia, these four countries share many social and historical characteristics. However, they differ in terms of area, population, infrastructure, economic level of each country, and public transport system, so we need a comprehensive evaluation comparison of the bus transportation system in these countries and the impact of GDP per capita on it. Moreover, evaluating the road network that serves each country and its proportionality with the number of buses, the country's size, and the population will be explored, because of the important location of these countries in Central Europe. Where it is considered a link between eastern and western Europe and plays an important role in terms of economic and tourism.

2. Methodology



The following types of general data were collected for the four countries from publicly available databases (Eurostat, Nation Master):

- The number of public transport buses registered for each country from 2013 until 2019.
- Population and area of each country.
- The length of paved roads for each country.
- Average annual GDP per capita.

The length of paved roads were considered as constant in the investigation period (from 2013 to 2019), because there is no clear, transparent, robust database for the Visegrad countries for each years.

The relationship between the number of buses for each country was compared with the four variables (area [km²], length of paved road network [km], GDP [EUR/capita] and number of buses) and comparing them with each other in order to show the extent to which the number of buses is proportional to the area of each country, the number of paved roads served, and the extent to which the economic level of the individual or the state affects the number of buses, and thus the percentage of use of public transport by buses for each country. The raw data are given in Table 4 at the end of this study.

2.1. Study Area

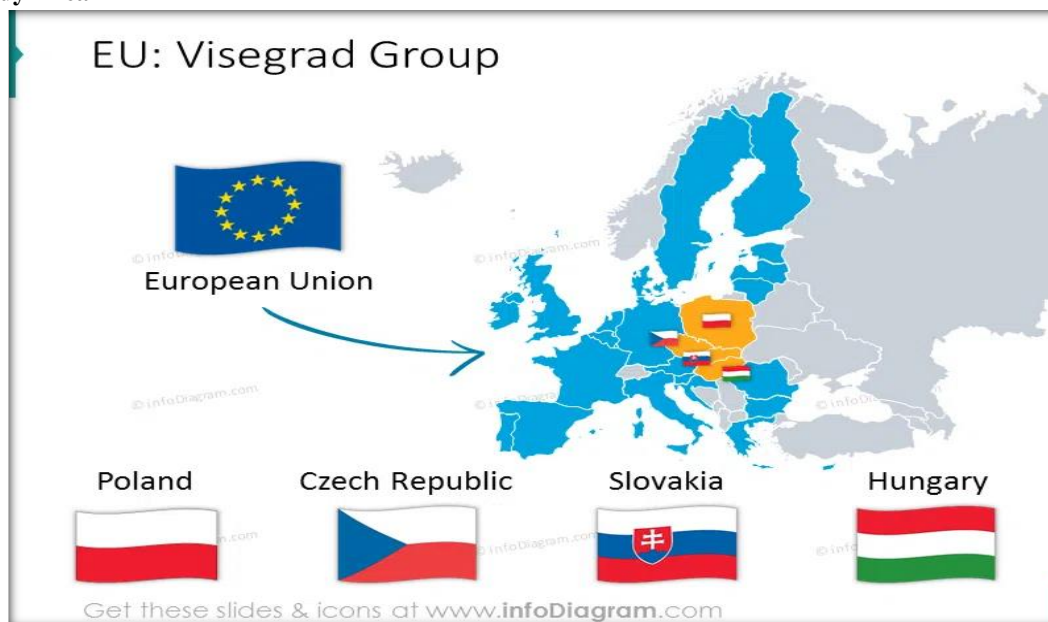


Fig.1. Location of case study countries(www.infodiagram.com)

Hungary is a landlocked country in Central Europe. The area of around 93,030 km² of the Carpathian Basin is bordered by Slovakia to the north, Ukraine to the northeast, Romania to the east and southeast, Serbia to the south, Croatia and Slovenia to the southwest, and Austria to the west. Hungary has a population of nearly 10 million (Horváth, 2000).

Poland is located at a geographic crossroads that links the forested lands of northwestern Europe to the Atlantic Ocean Sea lanes and the Eurasian frontier's fertile plains. The total area of 312,679 km² is the seventh biggest country on the continent. The Polish population is over 38,5 million people. Poland borders seven countries: Germany on the west, Czech Republic and Slovakia on the south, Ukraine, Belarus and Lithuania on the east, and Russia on the north. (Rdzany, 2014).

The Czech Republic or Czechia is a landlocked country in Central Europe. It is bordered by Austria to the south, Germany to the west, Poland to the northeast, and Slovakia to the southeast. The Czech Republic has a hilly landscape covering an area of 78,871 square kilometers and over 10 million people (Divíšek et al., 2014).



Slovakia is a landlocked country in Central Europe. It is bordered by Poland to the north, Ukraine to the east, Hungary to the south, Austria to the southwest, and the Czech Republic to the northwest. Slovakia's mostly mountainous territory spans about 49,000 km², with a population of over 5.4 million (Ištók and Plavčanová, 2015).

These four countries, which make up the so-called Visegrád Group, are located in the center of Europe, share boundaries, and have the same characteristics of society. They are also landlocked countries except for Poland, which has a larger population density and a larger area.

3. Result and discussion

Firstly, we can arrange the countries depending on the area as follows: Poland, Hungary, Czechia, and Slovakia. Furthermore, depending on the population as following Poland, Czechia, Hungary and Slovakia.

Table 1

Summary data in 2019

country	Total Buses	Bus/capita	Bus/km ²	Bus/km	Bus/GDP
Poland	91052	0.0023874	0.2911707	0.299513	6.581
Czechia	21484	0.0020345	0.272408	0.386035	1.016
Hungary	19500	0.0020093	0.2096211	0.278373	1.3
Slovakia	8974	0.0016445	0.1830121	0.235631	0.518

<https://ec.europa.eu>.

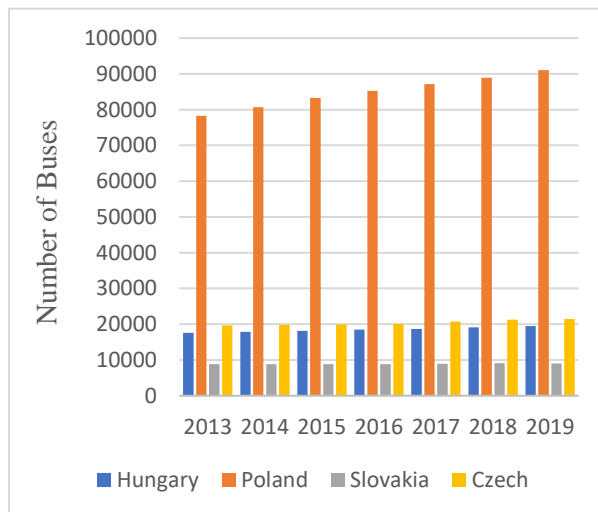


Fig. 2 No of buses

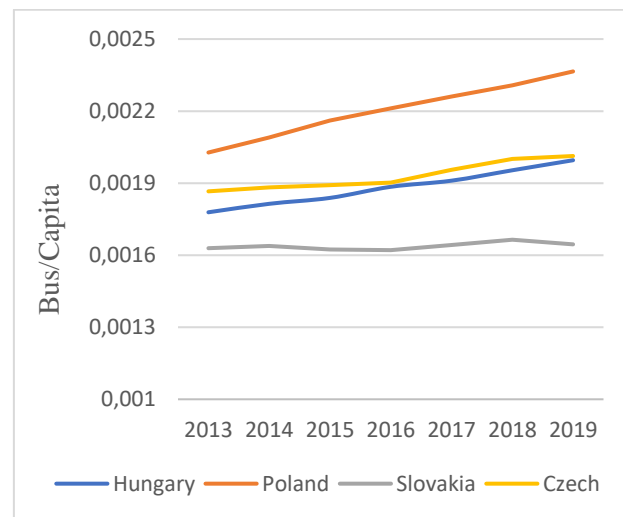


Fig. 3 Bus/ capita

Figure 1 shows that Poland has more buses than the other countries. This is expected because of its vast area and population, and Czechia in the second level before Hungary and finally Slovakia. Hungary's area is more than that of Czechia by 15%, but the Czech Republic has more buses. Figure 3 shows the percentage of buses per capita in each country. Poland takes the lead, followed by the Czech Republic, Hungary, and Slovakia. The Czech Republic is superior to Hungary in the bus/capita figure, despite the similarity in the population of both countries, considering the area of Hungary, which is 15% more than that of Czechia.

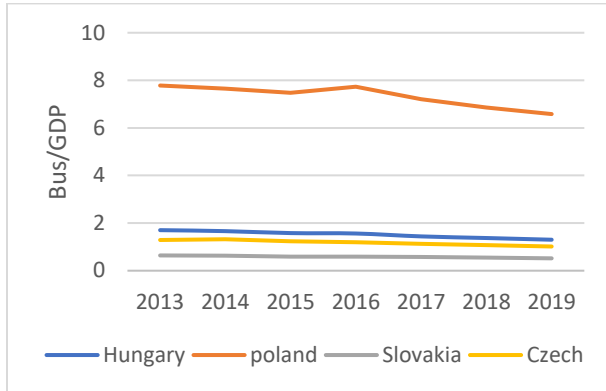


Fig.4 Bus/GDP

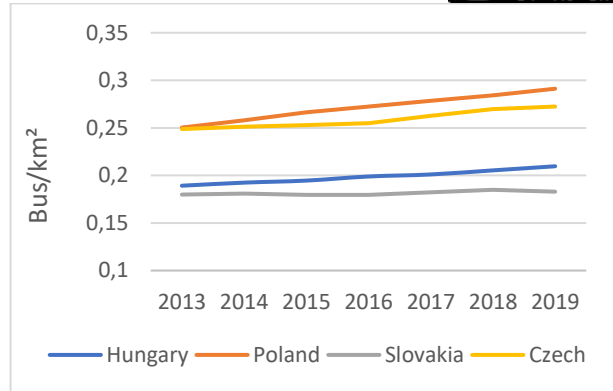


Fig. 5 Bus/ Km²

Figure 4 demonstrates how GDP per capita is correlated with the number of buses for these four countries. Poland has the highest Bus/GDP value due to the high number of buses and low GDP per capita, but generally, it decreases by 15% from 2013 to 2019. Slovakia has the lowest percentage of Bus/GDP because it has higher GDP, which affects the number of buses: it leads to a decrease in the use of buses as a mode of transportation, and thus the number of buses decreases due to the lack of use. To increase the use of buses in countries with higher GDP per capita, the performance of bus transportation must be improved in terms of reducing the waiting time, increasing the number of stations and facilitating access to them, and using modern buses that provide sufficient comfort factors.

Also, Figure 5 shows that the area covered by buses in Poland is high compared to other countries like Slovakia, which has the smallest area has a low Bus/km² value.

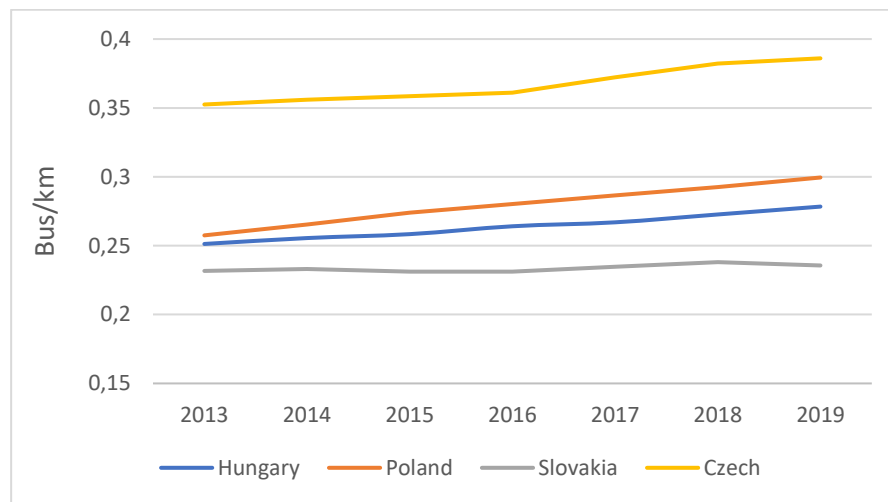


Fig. 6 Bus/ Km

Table. 2
Area and paved road.

Country	Czechia	Slovakia	Poland	Hungary
Area	78,867 km ²	49,035 km ²	312,710 km ²	93,025 km ²
Length of paved roads	129, 411 km	38,085 km	307,066 km	77,942 km
% km/km ²	1.64	0.77	0.97	0.83

<https://www.nationmaster.com/>

Figure 6 illustrates that Czechia has the highest percentage for Bus/km and it has the longest road network km/km², while Poland is the second and Slovakia is the last. In contrast, Slovakia has a high GDP and low area level compared with the other countries.

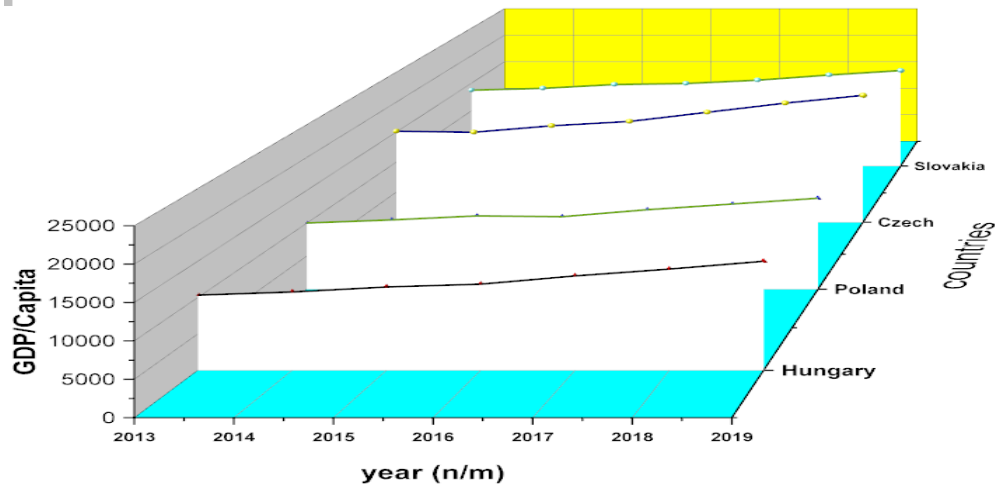


Fig. 7 The relationship between GDP and Capita

GDP/capita: The statistical description of the available data shows that the GDP/capita is inversely proportional to the demand for public transportation and, thus, the number of buses in each country. Poland has the highest number of buses and buses per capita and high Bus per GDP capita value but has the lowest income level (GDP). In contrast, Slovakia has a low population, small area, and high GDP. This leads to the lowest number of buses if income welfare is high (GDP/per capita), this shows that the increase GDP per capita is not linked to an increase in the number of buses or an increase in dependence on public transportation by buses.

Bus / km and Bus/ km²: Czechia has a better bus/km percentage than Poland, Hungary, and Slovakia. That means the paved road network in Czechia covers the country area very well, regarding to figure 6 it is suitable for transport services. With respect to the number of buses compared to the area of the country, Czechia comes in second after Poland, which needs to expand the transportation network and increase the number of buses in it to suit the number of residents and the area of the country. Also, this applies to Slovakia and Hungary to a lesser extent.

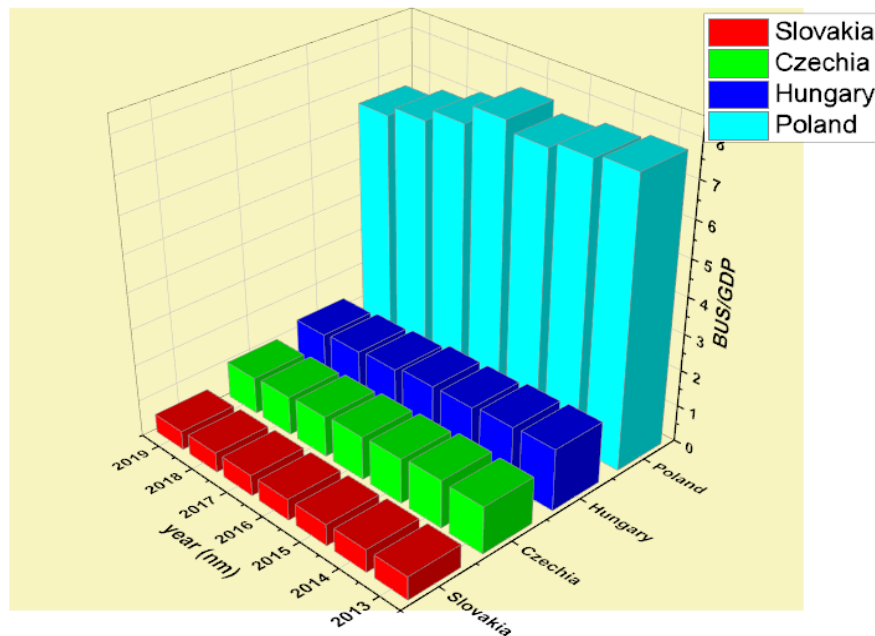


Fig. 8 The relationship between BUS and the GDP per capita

4. Conclusion and Recommendations

- Poland has the largest number of buses but that is offset by a low GDP per capita.



- Czechia has largest Bus/km percent and suitable Bus/capita percent.
- Hungary has good level regarding the proportionality of the number of buses with the number of the population and the coverage of buses from the area of the country.
- Slovakia is the highest in the GDP of its citizens and the lowest in terms of the number of buses, Bus/km, Bus/km² and Bus/GDP.
- For future work should be Focusing on the sustainability of public transport by buses by studying the percentage of emissions in these countries and their change with the increase or decrease in the number of buses in general and the extent of changes in the rates after increasing the number of electric buses.

Table 4. All data in our case study (2013–2019).

country	year	Population	GDP (country)	GDP per capita	No. of buses	Bus/capita	Bus/km ²	Bus/km	Bus/GDP
Hungary 93025 km ² 70,050 km	2019	9771796	146,526.1	14,994.79	19500	0.001995539	0.2096211	0.2783726	1.300451
	2018	9776358	136,054.6	13,916.69	19100	0.001953693	0.2053212	0.2726624	1.372452
	2017	9788941	127,024.7	12,976.34	18700	0.001910319	0.2010212	0.2669522	1.441083
	2016	9815104	116,255.7	11,844.57	18500	0.00188485	0.1988713	0.2640971	1.561897
	2015	9844246	112,791.0	11,457.55	18100	0.001838638	0.1945714	0.2583869	1.579744
	2014	9867901	106,263.8	10,768.63	17900	0.001813962	0.1924214	0.2555318	1.662235
	2013	9894639	102,239.7	10,332.83	17600	0.001778741	0.1891965	0.2512491	1.703307
Poland 312710 km ² 304000 km	2019	38493601	532,504.7	13,833.59	91052.00	0.00236538	0.2911707	0.2995132	6.58195
	2018	38521457	499,004.1	12,953.92	88907.00	0.002307986	0.2843113	0.2924572	6.863325
	2017	38532812	465,772.6	12,087.68	87122.00	0.002260982	0.2786032	0.2865855	7.207499
	2016	38532113	424,735.3	11,022.89	85205.00	0.002211272	0.2724729	0.2802796	7.729823
	2015	38553146	429,834.6	11,149.14	83304.00	0.002160758	0.2663938	0.2740263	7.471784
	2014	38581872	406,412.5	10,533.76	80659.00	0.002090593	0.2579355	0.2653257	7.657184
	2013	38607353	388,356.4	10,059.13	78280.00	0.002027593	0.2503278	0.2575	7.781985
Slovakia 49035 km ² 38,085 km	2019	5454147	94,437.5	17,314.80	8974.00	0.001645354	0.1830121	0.2356308	0.518285
	2018	5446771	89,874.7	16,500.54	9066.00	0.001664472	0.1848883	0.2380465	0.549436
	2017	5439232	84,669.9	15,566.51	8937.00	0.001643063	0.1822576	0.2346593	0.574117
	2016	5430798	81,265.2	14,963.76	8804.00	0.001621125	0.1795452	0.2311671	0.588354
	2015	5423801	80,126.0	14,773.03	8804.00	0.001623216	0.1795452	0.2311671	0.595951
	2014	5418649	76,354.5	14,091.05	8876.00	0.001638047	0.1810136	0.2330576	0.629903
	2013	5413393	74,492.8	13,760.83	8821.00	0.001629477	0.1798919	0.2316135	0.641022
Czechia 78867 km ² 55,653 km	2019	10671870	225,613.5	21,140.95	21484.00	0.002013143	0.272408	0.3860349	1.016227
	2018	10629928	210,970.5	19,846.84	21271.00	0.002001048	0.2697072	0.3822076	1.071757
	2017	10594438	194,132.9	18,324.03	20719.00	0.001955649	0.2627081	0.372289	1.1307
	2016	10566332	177,438.5	16,792.81	20097.00	0.001901985	0.2548214	0.3611126	1.196762
	2015	10546059	169,558.2	16,077.87	19950.00	0.001891702	0.2529575	0.3584712	1.240836
	2014	10525347	157821.30	14994.40	19808.00	0.001881933	0.251157	0.3559197	1.321026
	2013	10514272	159461.50	15166.20	19619.00	0.00186594	0.2487606	0.3525237	1.293601



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