

# The Level of Smart Mobility in V4 – Comparison of Capital Cities

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**Abstract.** Digitization and the development of the use of technology are becoming more and more a part of our daily lives. One of the current topics at the moment is sustainability. These two issues need to be able to come together. The use of digital technologies is important in order to improve the usability of resources and the functioning of processes throughout society. Through this article, we want to point out the current situation and level of the Smart Cities in V4 (Czech Republic, Hungary, Poland and Slovak Republic). We focus on the level of smart mobility in the capitals of the mentioned countries and then we compare them with each other. The aim of the first theoretical part of the contribution is to define the goals of Smart Cities and Smart Mobility and define their importance for the future. In the second analytical part, the aim is to compare the four capitals in Central Europe, belonging to the V4 and specify possibilities for the development of Smart Mobility in these cities.

**Keywords:** Smart City, Smart Mobility, digitization

**JEL classification:** *O39, Q56, R11*

## 1 Introduction

Sustainability is the theme of the 21<sup>st</sup> century. It concerns every single country, every city and basically every one of us. One of the areas that is constantly being taken over and examined in terms of sustainability is transport. Currently, there is a trend of living in suburban areas outside the city center, which causes people more and more to use means of transport to travel to work, school, acquaintances, etc. The goal of the future is to increase the sustainability of cities through the constant development of technology. To this a separate Smart City concept was created, which focuses on the application of technological innovations to the functioning of processes in the city. One of the important areas of the transition to Smart City is solving traffic problems in the city. Specifically, the so-called Smart Mobility Strategy. Putting it into practice is a

relatively demanding and lengthy process, but it is important that large cities in particular draw up a plan to put Smart Mobility into practice. We express how this works in practice in the article by identifying the situation in the field of Smart Mobility in four capital cities – Bratislava, Budapest, Prague and Warsaw.

## **2 Definition of Smart City and Smart Mobility**

Smart city concept is currently an increasingly accepted issue, which is dealt with not only by experts but also by metropolises of individual countries of the world. This issue is associated with the development of digital technologies and their usability in practice. There are several definitions of the term Smart City and it is quite difficult to define it clearly, as it consists of several sub-elements. According to the European Commission, Smart City is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business. [8] Professor M. R. Wade defines Smart City as an urban area that has become more efficient and/or more environmentally friendly and/or more socially inclusive through the use of digital technologies. [29] The issue of Smart City was already addressed in 2000, when Hall stated in his article that Smart City can be considered a winning strategy of the city, which uses technology to increase the quality of life in urban areas and consequently increase the quality of the environment through better services. [9]

As we have already mentioned, Smart City is a concept composed of several elements. One of these elements is Smart Mobility. Defining Smart Mobility is also not easy, as it is an issue that is relatively young and still under investigation. Albino et al. define in their article Smart Mobility as the use of modern information and communication technologies in order to improve urban transport. [28] A similar view is shared by Chun and Lee, who say that Smart Mobility is a concept of comprehensive smart services used in combination with smart technologies aimed at future transport systems. [6] The last definition we give is from Vanola, who says that Smart Mobility represents the availability of ICT in relation to modern, sustainable and safe transport systems. [1]

Based on the above definitions and opinions of experts, we can state that the concept of Smart City, as well as the concept of Smart Mobility is influenced by the level of use of modern technologies in the normal functioning of the city and transport. The speed of adaptation of individual cities to new available technologies varies, which we also analyze in the analytical part of this article, specifically in the four capital cities within the Visegrad Group.

## **3 Aim and methodology**

The aim of this article is to identify the level of Smart Cities in the V4 capital cities and then compare them with each other, focusing on the level of Smart Mobility. As part of literature review, we defined the basic terminology related to Smart City and Smart Mobility. We based on several opinions of professional authors, which allowed us to

summarize the current situation in the theoretical basis of Smart Mobility issues. In the practical part of the article, we compared the level of transformation of the V4 capital cities to Smart Cities through the implemented index – Smart City Index 2021. As SCI is relatively large, we focus our attention on the Mobility factor.

The main method used in writing the article was a comparison of four capital cities – Bratislava, Warsaw, Prague and Budapest. The comparison was based on the Smart City Index (SCI), which is constructed by the IMD World Competitiveness Center (IMD) and the Singapore University of Technology and Design (SUTD).

SCI methodology [13]:

1. SCI takes into account the views of the city's concerns on issues related to the technological applications available to them in the city.

2. The first edition of the SCI ranks 102 cities worldwide by capturing the perceptions of 120 residents in each city.

3. The index consists of two pillars: the Structure Pillar, which refers to urban infrastructure, and the Technology Pillar, which assesses the level of technological measures and services available to the population.

4. Each pillar is evaluated over five key areas: health and safety, mobility, activities, opportunities and governance.

5. The cities are distributed on the UN Human Development Index (HDI) score of the economy they are part of.

6. Within each HDI group, cities are assigned a 'rating scale' (AAA to D) based on the perceptions-score of a given city compared to the scores of all other cities within the same group.

7. The final results are presented in two forms:

- overall ranking (1 to 118),
- individually by pillars.

Furthermore, in the contribution, we used analysis (used in the examination of the data obtained from SCI), for the interpretation of the results we mainly used graphic representation in the form of bar graphs. At the end, we applied the method of summarization, through which we specified the conclusions based on performed analysis.

### **3.1 Object of research**

We focused our analysis on the capitals of Central European countries, which together form the Visegrad Group (V4). It is the capital of the Slovak Republic – Bratislava, the capital of the Czech Republic – Prague, the capital of Poland – Warsaw and the capital of Hungary – Budapest.

#### **Bratislava**

The capital city of the Slovak Republic has less than 440 000 inhabitants [31]. HDI is growing slightly year-on-year (specifically between 2018/2019 by 0,003 points). GNP per capita in PPP in dollars is also growing (an increase of 1 441 dollars). [10]

### **Prague**

The capital of the Czech Republic has around 1 300 000 inhabitants [32]. HDI is growing slightly year-on-year (specifically between 2018/2019 by 0,009 points). GNP per capita in PPP in dollars is also growing (an increase of 6 512 dollars). [13]

### **Warsaw**

The capital of Poland has around 1 700 000 inhabitants [33]. HDI is growing slightly year-on-year (specifically between 2018/2019 by 0,008 points). GNP per capita in PPP in dollars is also growing (an increase of 3 997 dollars). [14]

### **Budapest**

The capital of Hungary has around 1 750 000 inhabitants [30]. HDI is growing slightly year-on-year (specifically between 2018/2019 by 0,009 points). GNP per capita in PPP in dollars is also growing (an increase of 4 185 dollars). [11]

## **4 Results**

Based on theoretical background, it is clear that the development of technology is promoted in all areas of the society. A prerequisite for the future is the development of smart technologies into the functioning of cities. The speed of technology transfer and digitization is different. There are cities that are already almost fully digitized and we can call them Smart Cities. However, some cities are just embarking on a wave of digitization and technology advancement. In the practical part of the article, we therefore focus on comparing the level of smart in V4 capital cities. Specifically, we focus on one analyzed factor – Mobility, through which we determine the level of transition to Smart Mobility.

Among the cities that we can call Smart City, we can include Singapore, Zurich and Oslo, which in the SCI index ranked the first three highest ranks in 2021. Singapore thus defended its first place in 2020.

When we focus on the mentioned V4 capital cities, the best position was occupied by Warsaw. Out of a total of 118 countries, Warsaw ranked 75<sup>th</sup> in 2021. Compared to the previous year, Warsaw fell by 20 positions. In comparison, Bratislava occupied the 96<sup>th</sup> position in 2021, and the position also deteriorated by 20 places. The third analyzed city – Budapest, occupied the position just behind Bratislava (97<sup>th</sup>) in 2021. Even in this case, there was a year-on-year drop of 20 places. The largest drop was recorded in the capital of the Czech Republic (Prague), which occupied the 78<sup>th</sup> position, which represented a drop of 44 places.

We summarize the overall evaluation in Table 1. <sup>1</sup>

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<sup>1</sup> Specific results in the individual factors analyzed are available on the IMD website: <https://www.imd.org/smart-city-observatory/home/>.

**Table 1.** SCI 2021 and 2020 for V4 capital cities [13].

City	Smart city Rating 2021	Structure 2021	Technology 2021	Smart City Rank 2021	Smart City Rank 2020	Change 21/20
Bratislava	CC	CC	CC	<b>96</b>	76	- 20
Budapest	CC	CC	CC	<b>97</b>	77	- 20
Prague	CCC	B	CCC	<b>78</b>	44	- 34
Warsaw	CCC	CCC	CCC	<b>75</b>	55	- 20

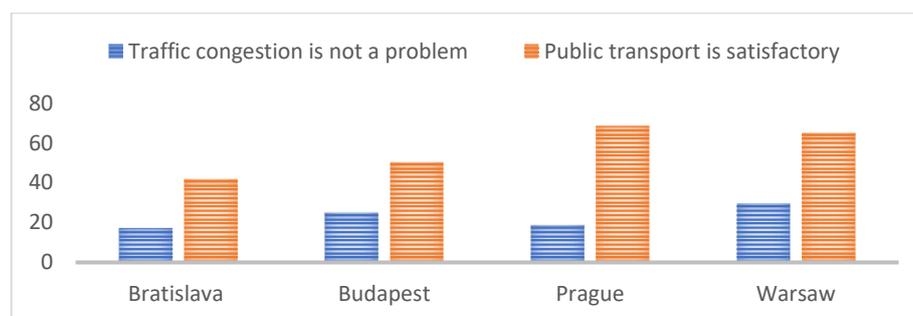
Source: IMD website: <https://www.imd.org/smart-city-observatory/home/> [accessed 25.06.2022]

Based on the above table, we can state that the transition to Smart City is at a comparable level in all 4 cities. A significant negative is the fact that all analyzed cities have significantly deteriorated year-on-year. It is therefore clear that none of the major V4 cities have managed to embark on a wave of digitization and the transition to smart technologies in cities.

We analyze the shortcomings of individual cities in separate subchapters.

#### 4.1 SCI factor Mobility in the first pillar Structures

SCI is divided into two pillars, both of which analyze the Mobility factor, which significantly affects the creation of Smart City. When we focus on the first pillar of SCI, we analyze mobility in terms of structure. Figure 1 shows the achieved values for mobility issues for the four cities analyzed in 2021.



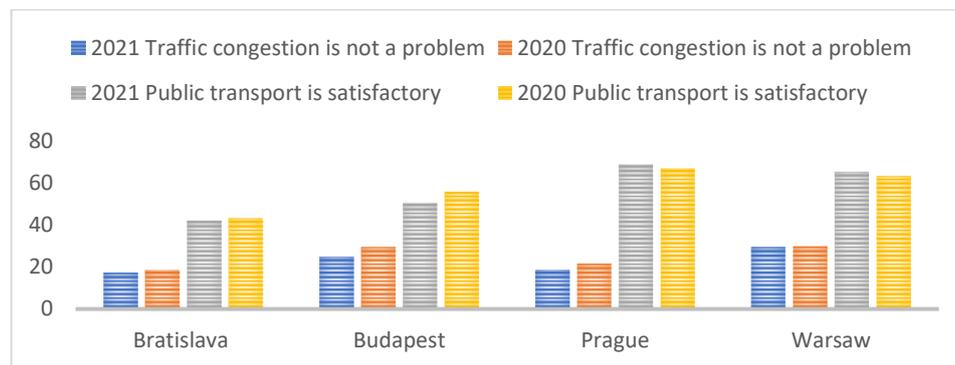
**Fig. 1.** Mobility in the pillar Structures 2021 in analyzed cities.

Source: own processing according to IMD World Competitiveness Center: Bratislava, Budapest, Prague, Warsaw.

It can be seen from Figure 1 that traffic congestion is a problem for analyzed cities. Budapest and Warsaw are at the average level of all analyzed cities on this issue. Bratislava and Prague are significantly below average. On the positive side, the inhabitants of all four cities are satisfied with public transport and the achieved values

of this indicator are above average. We can therefore deduce that the solution to this situation is to increase the use of public transport in cities. The conditions according to the SCI results are created enough for this, it is only necessary for people to realize the need to use them and thus facilitate transport in the city center.

When we compare 2021 and 2020, the mobility indicators did not show significant changes. A slight drop was recorded in Budapest, where satisfaction with public transport as well as with traffic congestion deteriorated.



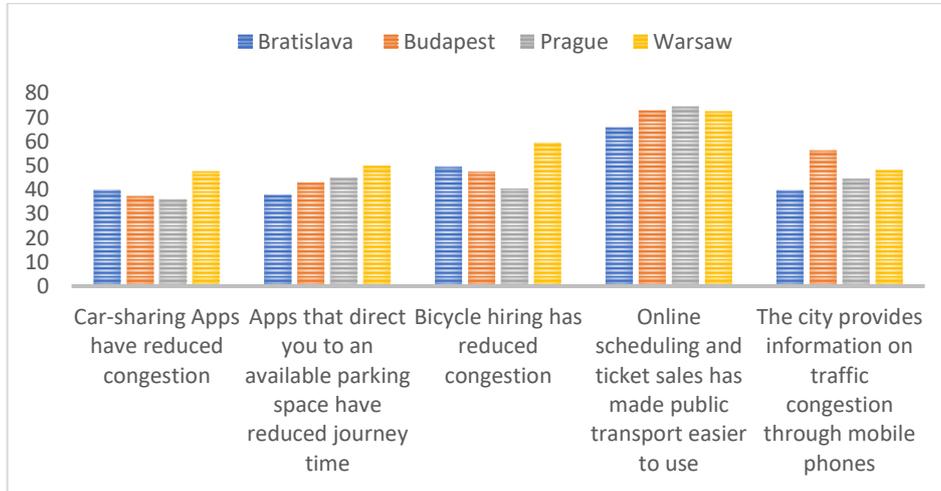
**Fig. 2.** Mobility in the pillar Structures 2021 and 2020 in the cities analyzed.

*Source: own processing according to IMD World Competitiveness Center: Bratislava, Budapest, Prague, Warsaw.*

The situation did not improve year-on-year in any of the analyzed cities. It is therefore necessary for cities to focus more on promoting the use of public transport and improve the transition to Smart Mobility.

#### 4.2 SCI factor Mobility in the second pillar Technologies

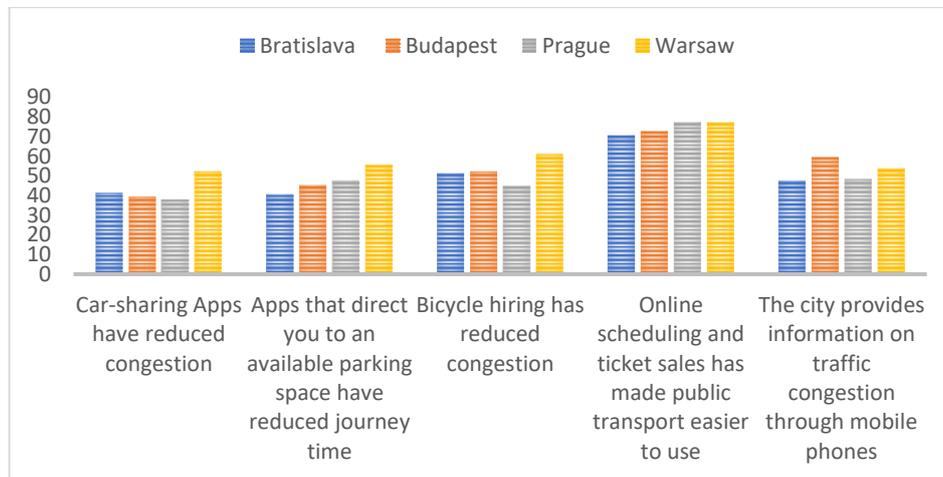
In this section we will focus on the analysis of the results of the SCI factor Mobility in terms of technology. Figure 3 shows the values for each Mobility indicator for 2021.



**Fig. 3.** Mobility in the pillar Technologies 2021 in the cities analyzed.  
*Source: own processing according to IMD World Competitiveness Center: Bratislava, Budapest, Prague, Warsaw.*

In terms of analyzed technologies, a different area is problematic for each city. In Bratislava, the problem is the application related to parking and information about traffic congestion via mobile phone. Other indicators are at the level of the average. In Budapest, the possibility of reducing congestion through car-sharing apps as well as parking-related applications is particularly problematic. The possibility of online scheduling and ticket sales within the use of public transport is the most perceived positively. In Prague, car-sharing applications are not perceived as a tool to reduce traffic congestion. The only indicator that reached above-average values is online scheduling and ticket sales in public transport. Warsaw ranked best in the analyzed indicators. The only slightly below-average result is the indicator “the city provides information on traffic congestion through mobile phones”. Other indicators achieved either average or above-average results.

Figure 4 shows the year 2020 for the Mobility indicators in the Technology Pillar.



**Fig. 4.** Mobility in the pillar Technologies 2020 in the cities analyzed.  
*Source: own processing according to IMD World Competitiveness Center: Bratislava, Budapest, Prague, Warsaw.*

All countries recorded a decrease in the analyzed indicators. This is not a significant decline, but all indicators deteriorated slightly year-on-year. The most significant decreases occurred in the indicator “the city provides information on traffic congestion through mobile phone”, the smallest decrease was recorded by the indicator “car-sharing apps have reduced congestion”.

### 4.3 Future of Smart Mobility in analyzed cities

Based on the results of the SCI, it is clear that the four cities analyzed have certain mobility shortcomings that need to be improved in the coming years. Each of these cities has a goal of gradual transformation into a Smart City as part of its development strategy.

Bratislava has a creative concept called Bratislava Reasonable City 2030 [3], the aim of which is to turn Bratislava into a so-called Smart City by 2030 through the development of several areas. One of these areas is also mobility. The strategic goal of Bratislava is sustainable and efficient traffic management, including the collection, analysis and use of integrated traffic data in the city. It wants to achieve this goal through several tools. The aim is to increase the supply and attractiveness of passenger transport by public transport and thus increase the quality of public space. Emphasis is also placed on the sustainability of environmental quality. The achievement of the sub-targets is measured through several clearly defined indicators. These include a reduction in the share of motorized individual transport to 35% in 2025, 25% in 2030 and less than 20% in 2040, an increase in the length of cycle paths built in Bratislava, a reduction in emissions from transport, etc. The following projects are currently underway in Bratislava, the aim of which is to improve the level of mobility in the city:

- Informatization of public transport in Bratislava, which focuses, inter alia, on the fitting of information boards using position data obtained from GNSS equipment in means of transport stops [7],

- Bikesharing, which is the largest in Slovakia in Bratislava and aims to develop cycling [2],

- Urban-E, which aims to develop electromobility and support the expansion of charging station infrastructure [21],

- Up! City, which focused on electric car sharing, is currently inactive [18].

We can state that Bratislava is trying to accelerate the process of transformation to Smart City through several projects.

Like Bratislava, Budapest has a strategy for becoming a Smart City. In particular, the Smart Budapest concept [22], which focuses on regional development, the environment, society and the economy. One of the goals is to ensure sustainable transport and proactive transport management in the city. In Budapest, they want to focus on increasing the use of public transport by 2030. Specifically the aim is to achieve that by 5% point growth in public transport half of all city traveling. [22] One of the goals is, of course, to increase the use of electric cars in the city. In order to achieve this goal, it is necessary to build a sufficient infrastructure in the city with enough charging stations. Proactive transport management is management that aims to increase traffic safety and reduce congestion through efficient urban logistics and intelligent mobility in Budapest. In Budapest, They focus on the development of Smart Mobility through several projects and strategies:

- The Mobility Plan in Budapest, which aims to improve Budapest's competitiveness and transport, as well as to improve the manageability of the city and surrounding areas on the basis of sustainability standards. [5]

- Budapest for All is a strategy that aims to protect the city's environment and habitability. [15]

- The Budapest Integrated Settlement Development Strategy is a comprehensive plan that sets out development trends and priorities in the city of Budapest. [20]

- Climate Strategy and Sustainable Energy and Climate Action plan [10].

- MOL Bubi is a bicycle sharing service. [17]

Budapest is set for a gradual transformation to smart using a variety of tools and paths.

Prague also has a concept for the development of smart elements in the city, specifically the concept of Smart Prague 2030 [19]. The concept is based on the use of state-of-the-art technologies to transform the metropolis into a more pleasant place to live. Of course, this concept also focuses on mobility in the city. Its challenges lie in air and noise pollution, traffic jams, the age of the vehicle fleet, the use of public transport and parking problems. The aim is for mobility in Prague to be clean, shared, intelligent, mobile and self-managing. Several projects are being implemented to develop mobility in the city:

- Intermodal route planner, which will contribute to the flow of traffic and reduce the environmental burden caused by car traffic in Prague. [25]

- Maas App – Single registration and single payment for mobility services [26].

- Multi-channel check-in system for public transport, which enables a comfortable and modern way of handling public transport passengers. [27]
- Data integration of P+R car parks in the catchment area of Prague, the aim of which is to reduce the burden in Prague through car parks outside the city limits. [23]
- E-carsharing, which creates space for a system of public car sharing. [24]

As in the previous two cities, the goal in Prague is to improve the level of Smart Mobility in the city.

Warsaw also has a concept focused on the development of the city towards Smart City, specifically Warsaw and Smart City. [16] This concept is divided into 6 key areas of development. One of them is mobility in the city, which aims to expand the use of public transport, make public transport more efficient and use new technologies in order to find sustainable solutions in transport. In Warsaw, there is so-called Veturilo project. It is one of the largest urban cycling systems in Europe. Thanks to this project, there is a total of 500 km long network of cycle paths in Warsaw. Furthermore, mobile applications are widely used in Warsaw, which are used to purchase tickets, parking tickets, timetables and the current location of public transport. Car-sharing, which has been operating since 2017, is a matter of course in this city. It is planned to put more than 140 electric buses into use in the future. The aim is for the city to use only electric cars in the future, while it is necessary to ensure, in particular, an increase in the number of charging stations. Another important project that will move Warsaw towards Smart Mobility is VaVel. This project uses big data from public transport and the Veturilo bike system. The result is the creation of an intelligent route planner, with the application designing the optimal route.

## 5 Conclusion

The future of our planet is in our responsible approach to daily activities. One such activity is travel and use of means of transport. The solution to traffic problems in cities is the Smart Mobility concept.

It turned out that in the capitals of the V4, the level of development of Smart Mobility is still in its infancy. All four cities still have several important challenges ahead of them, which they are elaborating on specific strategies focused on the built Smart City. In the article, we focused primarily on analyzing the position of the four main cities in the SCI. We focused our attention on the part of this index that examines the level of mobility in the city. Overall, the city of Warsaw has the best position in the SCI, ranking 75<sup>th</sup>. As 118 cities were analyzed, all four V4 capitals will not be ranked until the second half of the evaluation. The negative is that there was a significant year-on-year decrease of up to 20 or more places in all four cities. It is therefore necessary for these cities to focus on the gradual development of smart elements, as the cities of developed countries are starting to flee more significantly.

As far as mobility is concerned, in the analyzed cities there are problems comparable in several cases. Traffic congestion and the associated solution are a big problem. The topic of parking and related applications is also problematic. One of the goals in all four cities is to increase the attractiveness of public transport and reduce the traffic load. On

the positive side, all four cities have developed a development concept towards Smart City, which also includes a separate section focused on elements of Smart Mobility. The advantage is that individual cities are part of several projects aimed at streamlining transport in the city.

The conclusion is that cities are theoretically ready for the transition to Smart City, but in practical terms there is still a long way to go to real transformation. One of the important factors influencing the level of Smart Mobility in the city is, of course, the people whose efforts should be focused on using the new elements that the city offers them. Only by consensus of the city's activities and the activities of its inhabitants can the Smart City strategy be successfully implemented.

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