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Impact of the COVID-19 pandemic on smart city performance in Europe

Today's global shocks, such as the COVID-19 pandemic or the current war conflict, raise serious challenges to cities. Smart cities, as engines of innovation, can respond to these shocks and show resilience. However, there are significant differences in the performance of smart cities around the world, which have been further widened by the COVID-19 pandemic. In our study, we use the IMD smart city index to examine how the pandemic has affected European smart cities and how their ranking has changed in a global comparison. The results suggest that there have been major shifts in their rankings, and that some of the differences in the performance of individual cities during the pandemic can be traced back to different urban governance models. The changes in the ranking of smart cities highlight the fact that different urban governance models operate differently in times of crisis, especially in terms of measurable short- and long-term effectiveness. These results highlight the importance of complex and combined urban governance models to deal effectively and flexibly with external shocks.

Keywords: resilient city, smart city, IMD ranking, COVID-19, urban governance models.
JEL code: R12

Introduction

Cities play a major role in the global economy. According to World Bank data for 2018, their contribution to global GDP is approximately 80%. One of the main reasons for this is that more than 50% of the world's population lives in urban areas, and this proportion is expected to increase in the coming decades (UN, 2012; WHO, 2013). 70% of the population of the European Union lives in urban areas (European Commission, 2011).

Further concentration in cities could lead to global challenges such as waste management, resource exploitation, environmental pollution, poverty, unemployment, urban services, problems of economies of scale and so on (Iberdrola, 2021).

Rapidly evolving technologies can have a major impact on the development of cities: the application of new, innovative solutions can be key to addressing the complex problems that arise with the increasing urbanisation. In the context of urban development and its problems, experts (see for example Schuchmann, 2022; Pirisi, 2019; Zhang and Li, 2018; Wang et al. 2018, Buzási, 2017) frequently use the concept of resilience, i.e. the importance of having and developing the capacity to adapt to external conditions. According to the authors and literature on the topic, the key to resilience is the ability to adapt to external shocks – social, economic, - that ensures the well-being of the people living there and contributes to long-term sustainability (World Bank, 2016; Sebestyénné Szép et al. 2020; Buzási, 2017; Szép et al. 2021).

The COVID-19 pandemic, as the occurrence of an unpredictable and external shock, demonstrates the importance and relevance of the approaches of researchers working on the

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concept of resilient cities. Furthermore, it draws attention to some possible directions of development of the smart city concept and research, in which the concept of resilience is much more emphasized than in the past, due to new challenges. It also draws greater attention to the problems and deficiencies of some cities and their vulnerability to external shocks. The OECD's July 2020 Urban Policy Responses technical paper sets out ten key lessons for urban development. All of them point to the emergence of a new urban development paradigm towards inclusive, green and smart cities (OECD, 2020).

In this paper, we present a theoretical framework for smart cities, highlight the diversity of smart concepts, draw attention to some smart city models for analysing the performance of smart cities and discuss the concept of resilient cities in the context of the COVID-19 pandemic. After describing the IMD smart city index used for the analysis, we compare the smart city rankings for 2019, 2020 and 2021 for the top 10 European cities (EU-EFTA region), examining how the COVID-19 pandemic has changed their rankings and priorities. After comparing and interpreting the smart city rankings, we draw conclusions on the relationship between cities' development (smart performance) and resilience, outlining the different impacts of the pandemic shocks across the continent.

Theoretical framework of smart cities

The smart city concept emerged in the literature in the 1980s and 1990s in the context of technological development, the explosion of urban population growth, the complex problems associated with it (e.g. waste management, resource exploitation, pollution, poverty, unemployment) and the related modernisation of urban governance (Bizjan, 2014). In this sense, this concept is the result of a paradigm shift in urban development, with a focus on innovative solutions to urban problems (European Parliament, 2014).

Digital technologies offer practical solutions to the complex problems associated with the increasing concentration of the world's population in urban areas. At present, the implementation of wireless network sensors is the latest trend (Bizjan, 2014). At the same time, the smart city concept is all about modern urban management based on modern technologies and adapted to environmental conditions and available resources (Winkowska et al. 2019). There are a number of criticisms of the smart concept. A significant number of critical approaches address the importance of the social aspects, i.e. a society that can use smart technologies (Baji, 2017), as well as the security issues of data obtained from sensors and other devices (cybersecurity). This approach also raises important issues for the topic of this paper.

The literature on urban development uses several synonyms for the term smart city. Among these, the terms intelligent city, digital city are widely used. As with the synonyms, the picture is also varied as regards definitions: there is no common concept of its content and application, neither in the literature nor in practice. Some of the definitions highlight the role of ICT (Anthopoulos &Fitsilis, 2010; Washburn et al. 2010), others focus on the role of human and social capital (e.g. Caragliu, 2009; Schaffers, 2011), infrastructural aspects (Hall, 2000; Harrison et al. 2010) or the importance of organisational and design solutions (Toppeta, 2010; Washburn et al. 2010). According to Giffinger et al. (2007), the characteristic of a smart city is, in short, that it performs very well in the areas of economy, people, governance, mobility, environment, living conditions, and these areas have a number of attributes that can be measured by indicators.

As more European cities have followed the smart cities model in recent years, the smart concept is often and variously formulated in official EU documents. In 2011, the European Smart Cities Initiative defined three key elements in this area: (1) green technologies, (2) ICT technologies as management tools, (3) sustainable development (Think, 2011). The 2013 study

Smart Cities and Communities (2013) states that the main objective of smart city development is to improve the quality of life of the population, which is not only a technological but also a multidisciplinary and multi-stakeholder task.

The EU's 2018 definition is: 'A smart city is a place where traditional networks and services are made more efficient through digital solutions for the benefit of citizens and businesses. A smart city goes beyond the use of digital technologies to make better use of resources and reduce emissions. This means smarter urban transport networks, modernised water and waste management facilities, and more efficient ways of lighting and heating buildings. It also means more interactive and efficient city management, safer public spaces and meeting the needs of an ageing population' (European Commission, 2018).

International and national literature offers smart city models to analyse the performance of smart cities. At the international level, for example, Cohen's "Smart Cities Wheel" model (Cohen, 2015), Frost and Sullivan's model (2013), the Nature Based Smart City, Giffinger et al.'s model (2007), and at the national level, the IBM Smart City initiative is considered the most important study (Horváthné Barsi et al. 2011).
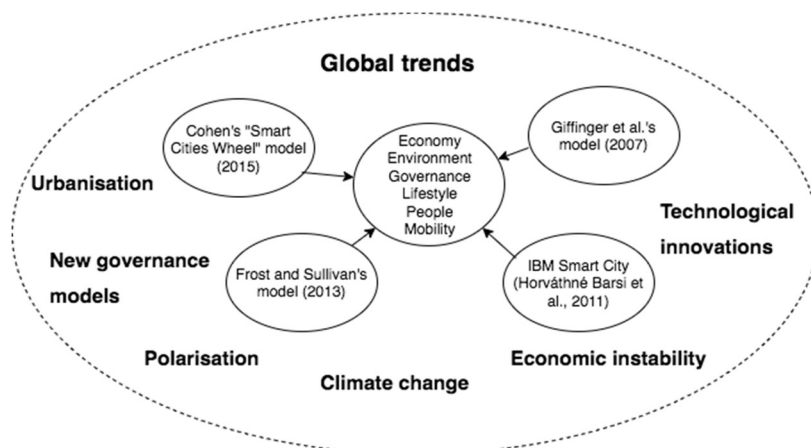

Figure 1: Common Cross Section of Smart City Models
Source: own compilation

An increasingly frequent concept in the context of analysing the performance of smart cities is resilience, i.e. the ability to respond to rapidly changing external influences and adapt to external conditions (for a summary of theoretical approaches to urban resilience, see for example Pirisi, 2019; Zhang and Li, 2018; Wang et al. 2018, Buzási, 2017). The smart city model of Fernandez-Anez et al. (2018) also includes global trends that affect cities to adapt to rapidly changing circumstances (resilience). At the core of the model are five smart city subsystems: environment, mobility and infrastructure, economy, people, living conditions and services. The subsystems are part of a macro-environment with environmental, technological and spatial impacts. The main trends affecting cities are interpreted as climate change, social polarisation, the need for new governance models, global urbanisation, economic instability, and the growing importance of new technologies.

In short, the concept of resilient cities is about the ability to adapt flexibly to often unpredictable external conditions, i.e. to maintain or rapidly restore urban functions in the case of external shocks (Buzási, 2017). Adaptability is therefore the key to resilience, which shows how resilient a city is and how rapidly it can respond to external impacts (World Bank 2016). In exploring the relationship between smart cities and resilience, Sebestyénné Szép et al. (2020) argue that 'adaptability is what enables a city to ensure the well-being of its inhabitants

and contribute to long-term sustainability. In other words, these two concepts (adaptability and sustainability) go hand in hand' (Sebestyénné Szép et al. 2020, 356).

At the same time, the speed and form of responses to shocks may also differ due to the different governance models of cities. Those using a top-down urban governance model and those using a bottom-up approach (taking into account the needs and preferences of the population) may not be equally successful in shock situations. Duggal (2020) argues that top-down planning should be combined with multi-level, integrated urban governance to respond effectively and flexibly to urban shocks (e.g. pandemics). Nowadays, a new form of urban governance model (in addition to the classic triple helix and its quadruple-helix version with civil society) is the penta-helix approach, which proactively integrates the participation of social entrepreneurs and activists (Calzada, 2020). This helps to better respond to problems arising from a changing environment and can increase the resilience of cities, thus proposing a kind of co-creation model.

The COVID-19 pandemic has raised awareness of the importance of the correlation between smart cities and theories that take into account externalities (such as the concept of resilient cities). Expectations for smart cities were already set out in documents published by international organisations at the beginning of the pandemic: for example, the OECD (2020) technical paper on smart cities and inclusive growth mentions that harnessing the benefits of smart cities will be particularly important to help cities and countries to cope with the crisis caused by the pandemic. At a time of physical distance and isolation, digital technologies have an important role to play in delivering real-time life-saving information, ensuring the continuity of key public services (e.g. through distance learning) and bridging social isolation (OECD, 2020). According to Borruso and Balletto (2020), the health emergency of the COVID-19 pandemic highlighted that the Smart City model refers to permanent growth scenarios. The shocks and downtime caused by the pandemic situation made clear the vulnerability of cities in terms of primary services such as health, education and mobility. In the debate on smart cities, the focus has shifted to 'soft' elements such as social networks and applications. In their paper, the authors suggest some possible directions for the development of smart city concepts and research in the light of the new challenges posed by the COVID-19 pandemic: they argue that in the future, in order to reduce the digital divide, attention should be paid to networks for online learning and working, to address the gap between centre and periphery, and to reliable and fast public or private networks. Another aspect highlighted by the authors relates to relational and social characteristics: the epidemic situation has further highlighted the gap between digital illiterates and literates in society, despite access to digital technologies. This was very much reflected in the difficulties of organising online education (Borruso and Balletto, 2020).

The aim of this study is to examine the changes in the order of smart cities in Europe in the context of the COVID-19 pandemic, from which the authors draw conclusions on the relationship between the development (smart performance) and resilience of cities, outlining the different effects of the pandemic shock on the continent.

Differences in the ranking of smart cities in Europe

In our study, we analyse the performance of European smart cities and the impact of the COVID-19 pandemics on their ranking position using the IMD (International Institute for Management Development) Smart City index, which is the best of the currently available indicators to check the impact of the epidemic among the smart city rankings, as it includes data for 2019, 2020 and 2021, unlike other similar rankings. The IMD Smart City index (sometimes SCI in the following) was created in 2017 by two institutions, IMD and the Singapore University of Technology and Design (SUTD), to create a smart city index that

focuses on the economic and technological aspects of smart cities, as well as their "human dimensions" (quality of life, environment, inclusiveness). In their definition, a "smart city" is an urban environment that applies technology to enhance the benefits and reduce the shortcomings of urbanisation (IMD, 2019, p. 4). It adopts a holistic approach, aiming to explore different urban dimensions to see how cities can be made better through smart applications. The methodology relies primarily on the perceptions of those living and working in the cities studied, while recognising that not all cities start from the same level of development, nor have the same assets and benefits.

The index creation covered two periods. In the first phase, case studies of smart cities at different stages of development were collected to improve the relevance of the model behind the SCI. After that the second phase dealt with the prototype version of the SCI, which was published in 2019, creating a global ranking of smart cities.

> The latest Smart Cities Index ranks 118 cities worldwide, based on the opinions of 120 inhabitants in each city. Residents are asked for their views on two pillars: the structures pillar, which asks about the existing infrastructure of cities, and the technology pillar, which describes the technology services available to residents. Both pillars are assessed along five key areas: health and safety, mobility, activities, opportunities and governance. In addition, the index summarises the priority areas that respondents consider to be of high importance for their city. Survey respondents were asked to select the five most important priorities for their city from a list of 15 indicators (IMD, 2021a). The ratings for each city were calculated based on the city's performance within the group as determined by the country's HDI (Human Development Index) score. Cities are ranked and positioned in clusters (A-D) based on the home country's HDI value, with an increase in the number of letters (e.g. AAA) indicating a more prominent position within the cluster.

According to the introduction of the latest report (IMD, 2021), the pandemic will have serious consequences and changes for cities and their population. However, these will not completely overwrite the other fundamental urban problems (including, for example, climate-related issues) that arise from high population concentrations. As this year's report shows, quality of life, safety, mobility and waste management remain high on the list of problems around the world. However, the acceleration of digitalisation, for example, has changed some perceptions, leading to significant differences in the rankings. In this context, some smart cities have succeeded while others have partially failed to meet the challenges (IMD, 2021a).

We have checked the Top 10 European (EU-EFTA[22]) cities' position in the rankings that have been included in the analysis since the creation of the index (so which are members of SCI in all three years to maintain a stable set of cities), although the number of cities included in the smart index is increasing yearly (102 in 2019, 109 in 2020 and 118 in 2021). The ranking and its change can be seen in Table 1 below.

Table 1: Position of the top 10 European cities in the IMD smart city index rankings (2019, 2020, 2021)

2019			2020			2021		
city	position	overall rating of the city	city	position	overall rating of the city	city	position	overall rating of the city
Zurich	2	AAA	Helsinki	2	AA	Zurich	2	AA
Oslo	3	AA	Zurich	3	AA	Oslo	3	AA
Geneva	4	AA	Oslo	5	AA	Helsinki	6	A

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[22] EU-27, UK and the EFTA members: Norway, Lichtenstein, Iceland and Switzerland.

2019			2020			2021		
city	position	overall rating of the city	city	position	overall rating of the city	city	position	overall rating of the city
Copenhagen	5	AA	Copenhagen	6	AA	Copenhagen	7	A
Helsinki	8	A	Geneva	7	AA	Geneva	8	A
Bilbao	9	A	Amsterdam	9	A	Bilbao	10	BBB
Düsseldorf	10	A	Düsseldorf	13	A	Vienna	11	BBB
Amsterdam	11	A	Bilbao	24	BBB	Zaragoza	15	BBB
Vienna	17	BBB	Vienna	25	BBB	Amsterdam	17	BBB
Zaragoza	49	BB	Zaragoza	48	BB	Düsseldorf	20	BBB

Source: own editing

The data in the table above shows that there have been major changes in the ranking positions, e.g. Zaragoza has made significant progress (moving up from 49th to 15th place with a positive change in its overall rating). Besides that, several shifts happened in the ranking, e.g. Helsinki, Amsterdam and Vienna all showed a rather volatile annual trajectory. Helsinki and Amsterdam, after improving in 2020, declined more seriously in 2021, while Vienna, after deteriorating in 2020, improved for 2021. However, the European top of the index has been stable over the three years, with Zurich, Oslo and Helsinki leading both the European and global rankings, although Geneva and Copenhagen also hold good positions (these are particularly valuable in accounting for the change in the overall number of cities, which has increased from 102 to 118 cities worldwide). In parallel, however, Amsterdam and Düsseldorf have lost their previously favourable positions.

The first wave of COVID-19 led to a deterioration in the position of Bilbao and Vienna, which stabilised and improved in both cases by the second year. The biggest losers are Amsterdam and Düsseldorf, mentioned above, while the winner is Zaragoza. The pandemic also brought changes in the overall ratings, as there are no AAA-rated European cities since COVID-19, and the number of cities in the AA and A categories has also narrowed. However, the Top 10 European cities are rated at least BBB or better by 2021. The position changes are illustrated on the map below.
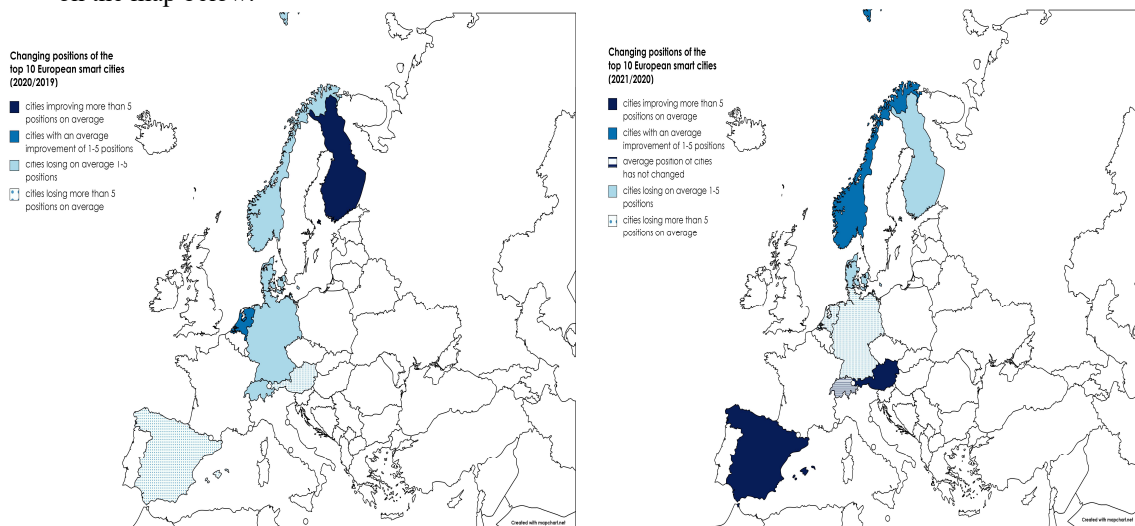

Figure 2: Changes in the city positions in the first and second year of Covid-19
Source: own compilation based on IMD (2019; 2020; 2021a)

Note: The countries' colour indicates the performance of the Top 10 city of that given country.

Based on the above shifts, the two best performing cities in the first year of the pandemics were Helsinki and Amsterdam, in terms of improving their position. Both have a strong bottom-up and co-creation approach, with the number of living lab initiatives being one of the strongest in these cities. The situation is similar in Zaragoza, where the development of the co-creation model started around 2019 and its results can be seen in the improvement of positions over the years (Glasco, 2018). In contrast, Vienna and Bilbao, with a strong top-down approach, have lost their positions a lot in the first year of the pandemic (severe restrictions, top-down management), which casts light on the functioning of different models during a crisis (Calzada, 2017).

The second year of the pandemic brought major changes in the ranking, with cities that had worked well in the short term with bottom-up management (Amsterdam, Helsinki) losing ground, while top-down strategies turned out to be a more effective way of dealing with the crisis in the longer term. This is underlined by the fact that, besides Zaragoza, Vienna and Bilbao have improved their rankings the most.

The IMD calculated the position of cities along two main dimensions (structure and technology) for each city, in each case based on a population sample of 120 inhabitants of the city concerned. The structures pillar refers to the existing infrastructure of cities, while the technology pillar describes the technologies and services available to residents (IMD, 2021b). Each pillar is assessed - as mentioned above - along five key areas: health and safety, mobility, activities, opportunities and governance. For the structures factor, respondents were asked to choose from four options: strongly agree, agree, disagree, and strongly disagree. However, for the technology factor, respondents could also select the no option (don't know/this technology is not available in my city) in addition to the previous four.

Among the technologies, we have examined the three factors considered as most problematic (below 50% satisfaction) in the cities, revealing some similarities, both in terms of its trend and in the problem areas (Table 2).

Table 2: Perceived problems of the technology pillar in Europe's leading smart cities

city	2019	2020	2021
Amsterdam	effective air pollution monitoring application	**effective air pollution monitoring application**	*effective air pollution monitoring application*
	car sharing apps reduces congestion	**car sharing apps reduces congestion**	**car sharing apps reduces congestion**
	online public access/monitoring to city finances	**online public access/monitoring to city finances**	online public access/monitoring to city finances
Vienna	car sharing apps reduces congestion	effective air pollution monitoring application	*effective air pollution monitoring application*
	app that direct you to available parking space	**app that direct you to available parking space**	*app that direct you to available parking space*
	online public access/monitoring to city finances	*online public access/monitoring to city finances*	online public access/monitoring to city finances
Bilbao	car sharing apps reduces congestion	**car sharing apps reduces congestion**	*car sharing apps reduces congestion*
	online public access/monitoring to city finances	*online public access/monitoring to city finances*	online public access/monitoring to city finances
	online voting (participation)	**online voting (participation)**	*online voting (participation)*
Düsseldorf	effective air pollution monitoring application	*effective air pollution monitoring application*	*effective air pollution monitoring application*
	car sharing apps reduces congestion	**car sharing apps reduces congestion**	**car sharing apps reduces congestion**

	bicycle hiring possibility	**bicycle hiring possibility**	online public access/monitoring to city finances
Geneva	car sharing apps reduces congestion	**car sharing apps reduces congestion**	*car sharing apps reduces congestion*
	app that direct you to available parking space	**app that direct you to available parking space**	*app that direct you to available parking space*
	online public access/monitoring to city finances	**online public access/monitoring to city finances**	**online public access/monitoring to city finances**
Helsinki	car sharing apps reduces congestion	*car sharing apps reduces congestion*	*car sharing apps reduces congestion*
	-	-	app that direct you to available parking space
	-	-	information on traffic congestion through mobile phones
Copenhagen	effective air pollution monitoring application	**effective air pollution monitoring application**	**effective air pollution monitoring application**
	car sharing apps reduces congestion	**car sharing apps reduces congestion**	*car sharing apps reduces congestion*
	online public access/monitoring to city finances	**online public access/monitoring to city finances**	*online public access/monitoring to city finances*
Oslo	car sharing apps reduces congestion	effective air pollution monitoring application	*effective air pollution monitoring application*
	app that direct you to available parking space	*car sharing apps reduces congestion*	**car sharing apps reduces congestion**
	-	**app that direct you to available parking space**	*app that direct you to available parking space*
Zaragoza	CCTV cameras has made residents feel safer	**car sharing apps reduces congestion**	**car sharing apps reduces congestion**
	car sharing apps reduces congestion	**online public access/monitoring to city finances**	**online public access/monitoring to city finances**
	online public access/monitoring to city finances	online szavazás (részvétel)	**online szavazás (részvétel)**
Zurich	effective air pollution monitoring application	**effective air pollution monitoring application**	effective air pollution monitoring application
	car sharing apps reduces congestion	**car sharing apps reduces congestion**	car sharing apps reduces congestion
	app that direct you to available parking space	app that direct you to available parking space	app that direct you to available parking space

Source: own editing
***Bold** markings in the 2020 and 2021 results columns indicate positive shifts (increasing satisfaction). *Italics* indicate cases where there was a significant deterioration/regression (decreasing satisfaction) in the data.

The table shows that Europe's leading smart cities face similar problems in the technology pillar, with 92% of the cases showing the same factors for all cities. However, it can also be said that in two thirds of cases, by 2020, public perceptions of these problems had improved markedly, with only 16% of cases showing a deterioration. However, as the pandemic situation intensified, by 2021 the problems had deepened, with a significant drop in half of the cases, some below the 2019 levels, and only one-quarter of problematic factors showing a positive shift. Therefore, the pandemic also had an impact on technological factors and their development. It can be the result of changes in the prioritisation/reallocation of the financial resources to deal with the pandemics in individual cities. Helsinki has particular significance, where in both 2019 and 2020 only one factor was below 50% satisfaction, but by 2021 there were five such factors.

In addition to the above, the IMD identified 15 priority axes from which respondents were asked to select the 5 most relevant (critical) factors/problems for the city. A higher score indicates a more specific issue. The 15 factors considered are affordable housing, safety, air pollution, public transport, road congestion (traffic jams), green spaces, basic services, recycling, public education, unemployment, social mobility, citizen involvement, full employment, energy efficiency (replaced by health services from 2020[23]) and corruption (IMD, 2021a). A review of these also shows a change in public attitudes towards the problems. We have looked at the changes in these priorities for all the cities studied, and the results are summarised below. The analysis of the cities is represented by the example of Helsinki (Figure 3), which supports most of our findings.

Several conclusions can be drawn from the changes in priority axes, and our analysis focused on the components that are likely to change as the epidemic situation intensifies, which show the short-term response of cities to pandemics and highlight their short-term resilience. We aimed to examine the changes detailed in the theoretical overview in practice.
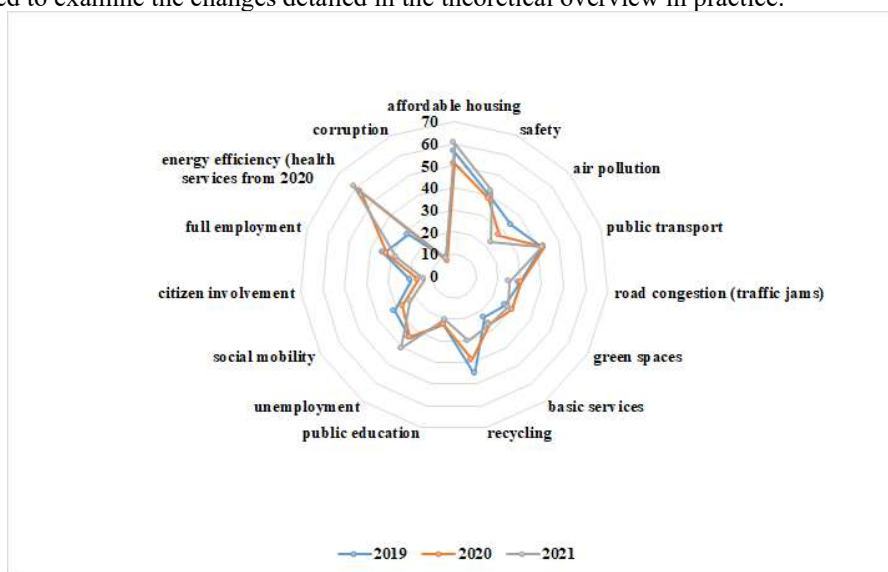

Figure 3: Change in the priority axes (order of importance of problems) in the case of Helsinki
Source: own editing based on IMD (2019; 2020; 2021a)

Affordable housing is the most important issue in most of the cities surveyed, and is the number one issue in most cities, with increasing importance between 2019 and 2021. As a result of population growth and the economic problems caused by the pandemic, cities are experiencing rising housing prices. The biggest shift has been in Copenhagen, where the inhabitants' perception of the problem has increased from 49.2% in 2019 to 71.7% in 2021. However, it is not this city that has the highest score, but Geneva, with a score above 80%. From 2020 onwards, the role of health services, which is being brought in by changing global issues, increased in almost all cities from 2020 to 2021 and gained a prominent place in the ranking. By 2021, two geographically distant cities, Helsinki (61%) and Zaragoza (45.2%) had the highest scores, while the lowest was in Zurich (11.3%).

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[23] Changing priorities also points out the importance of the intensifying pandemic situation as a new shock to cities.

At the same time, the pandemic shutdown caused serious labour market problems in most cities around the world, as can be seen in the unemployment factor of the smart cities surveyed (in many cases there has been a significant increase, with changes in 11 and 6 percentage points in Bilbao and Helsinki respectively). The shutdowns have also had a positive effect on reducing air pollution problems in several cities and, in conjunction, reducing the challenges of public transport.

The transformation and value shifts caused by the pandemics have led to an increase in the share of non-cash transactions in daily payments in almost all Top 10 cities, with the traditionally well-performing Nordic smart cities leading the way (Figure 4).
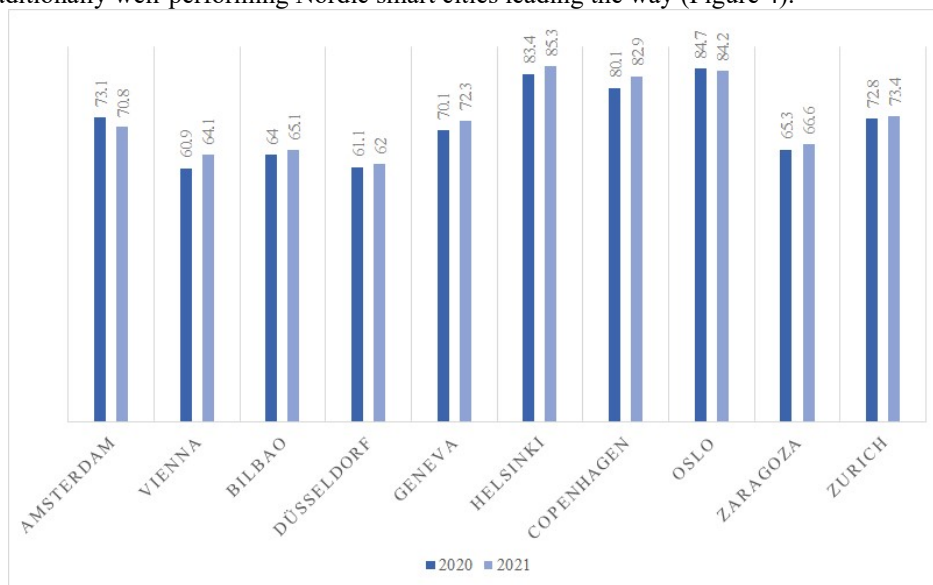

Figure 4: The importance of non-cash transactions in the daily transactions in the leading European smart cities
Source: own edits based on IMD (2019; 2020; 2021a)

It can be seen that except for Amsterdam and Oslo, where there was a slight decrease in the data, the importance of non-cash transactions in the total turnover increased in all cities, indicating the changes that occurred during the pandemic. However, the disparity among the best cities is also indicated by the fact that Düsseldorf had a value of 62% in this period. According to the results of a Finnish consumer survey, in 2020 only 6.2% of Finns used cash in their daily payments. In addition, the results also showed that only 35% of all transactions were made in cash in 2020, which is also the lowest value in a European comparison (compared to 83% in Spain and 77% in Germany, for example) (Harju and Snellmann, 2021).

Summary

The COVID-19 pandemic is a global shock, drawing attention to the close link between technology and urban development, the concept of resilient cities, and the problems, shortcomings and vulnerabilities of individual cities. According to the latest IMD report, 2021, in addition to addressing basic urban problems, the epidemic situation is leading to major changes and new challenges in cities (IMD, 2021a). These changes are particularly significant in large cities where the population is concentrated in higher density. These new challenges call for rapid and effective solutions, but not all cities have the necessary flexible planning

mechanisms in place. Traditional urban planning sets long-term growth targets and plans the political, technological and social processes to achieve them. In contrast, resilient urban planning is a new kind of flexible urban planning that takes into account both the need to accelerate change leading to recovery and the complexity and systemic interactions of urban ecosystems and their various contexts (Kakderi et al. 2021). Experts emphasising the importance of resilient urban planning (e.g. Duggal, 2020; Calzada, 2020; Kakderi et al. 2021) argue that the speed and form of responses to shocks may also differ between cities, due to different governance models. The authors cited propose complex and combined urban governance models for effective and resilient management of urban shocks, with an emphasis on technology in terms of its ability to mediate and manage complexity in a meaningful way, improve responsiveness, and provide flexible spaces for participation and creativity.

In this study, we compared the rankings of smart cities in 2019, 2020 and 2021 for the Top 10 European cities (EU-EFTA region) in the context of the COVID-19 pandemic and the need for resilient urban planning. We examined how the pandemic has led to shifts in the ranking of the indicated cities and their priorities. The results show a strong correlation between the development (smart performance) and resilience of cities, in particular in terms of the urban governance model applied. The changes in the ranking of smart cities highlight that different urban governance models perform differently in times of crisis, especially in terms of their short- and long-term measurable effectiveness. In our analysis, we found that in the first year of the pandemic, there were significant changes in the ranking positions: for example, Zaragoza made huge progress. There have also been shifts, for example in the case of Helsinki and Amsterdam, which improved their position with a bottom-up and co-creation approach, or in the case of Vienna and Bilbao, which lost their positions with a top-down approach.

In the second year of the pandemic, there were further shifts in the rankings, with cities that had worked well in the short term with bottom-up management (Amsterdam, Helsinki) losing ground, while top-down strategies appeared to be a more effective way of dealing with the crisis in the longer term (together with Zaragoza, also Vienna and Bilbao), improving their rankings the most. These results highlight the importance of complex and combined urban governance models to deal effectively and flexibly with external shocks.

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