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THE IDEA OF A SMART CITY IN THE DEVELOPMENT STRATEGIES OF POLISH VOIVODESHIP CITIES – A GAP OR A POTENTIAL?

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Purpose: The concept of smart city has entered into discussion on urban development. Its applications in large and smaller cities are widely discussed in scientific publications, but on how to link the smart city concept with strategic documents - not so largely. The aim of the article is to verify the literature gap, as well as the degree of consideration of the concept of smart city in regional cities.

Design/methodology/approach: Bibliometric analysis of publications combining smart city themes and strategies available in the Scopus database served to answer the question whether the scientific literature corresponds to the current scale of application activities of the smart city idea. Polish voivodeship cities strategic documents' analysis was focused on the main dimensions of the smart city concept they hold, used NLP (Natural Language Processing) methods.

Findings: The literature on the implementation of the concept of smart cities in city strategies focuses on individual aspects of this concept – multidimensional in its essence. More comprehensive research is needed on balancing the goals and perspectives of city stakeholders. Strategies of cities analyzed for the implementation of smart solutions turn out to be fragmented – they focus on (from the most popular) smart economies, life, mobility, environment, governance to smart people. In addition, these strategies are mainly postulative, and the goal of cities is to obtain the status of a smart city rather than support it (only Lublin and Krakow declare this).

Research limitations/implications: Strategic documents alone are too alike to let conclude about the implementation of the smart idea in individual cities. They should be completed with qualitative data. The NLP tools applied, although they provide interesting results, need to be tuned on a larger set of texts than accessible.

Practical implications: Voivodeship cities shape strategies that are too similar to actually compete with each other. Thematic modelling of city-specific documents can unhide context that have not yet been recognized while reflecting their potential to stand out.

Originality/value: The results of topic modelling can reveal latent themes related to the city they manage to city authorities. The gap in theory needs completion by research on the relationship between the smart city concept and urban strategies.
Keywords: smart city, city strategy, thematic modelling, CLARIN.
Category of the paper: Research paper with literature review.

1. Introduction

Currently, the world is undergoing huge changes. The pace of urban development is enormous. At the beginning of the 19th century, less than 1% of the population lived in cities. Within a hundred years, this percentage increased to 13%, and at the turn of the millennium it was 47%. In 2007, the Rubicon was crossed for the first time – then the population of cities exceeded the number of people living in rural areas. It is predicted to reach 68% by 2050 (ESA, 2018). The cities themselves are also growing, reaching the status of megacities with more than ten million inhabitants. From Tokyo to Lagos, from New York to Mumbai, this phenomenon is transforming the socio-economic landscape of the globe as shown in Figure 1. Larger and larger agglomerations are becoming magnets attracting people looking for a better life, work, education or access to advanced services.

But giant urban centers, while vibrant and dynamic, face many problems: infrastructure often cannot keep up with the needs of a growing population, leading to increased congestion, pollution, overloading of transportation systems, etc. These transformations pose huge challenges for city authorities, force a new approach to management and the search for innovative ways to solve growing problems. As a result, modern technologies are increasingly used to enable intelligent management of resources and optimization of urban processes – more cities want to be smart.

Although the idea itself sometimes looks like a fashion, introducing concepts such as "smart management", "smart city" or "technology of the future" into the discussion about cities, nevertheless, "smart city" in the face of urban challenges – becomes a necessity. Smart management is essential for city leaders who need to improve their decisions, introduce sustainable technologies, and react quickly based on real-time data. The key to its implementation is the proper planning of activities at the level of strategic documents.

The aim of this article is to confirm the gap in the connection between the idea of smart city and the development strategies of voivodeship cities and the scope in which the assumptions of smart city are implemented in strategic documents. The question was sought whether and to what extent voivodeship cities consider all six dimensions of smart city developed by the University of Vienna, including smart economy, mobility, environment, residents, quality of life and management, in their development strategies. In addition, an attempt was made to find those areas of activity of local government units in which smart solutions are of particular importance, as well as to find the cities that are declaratively the smartest.

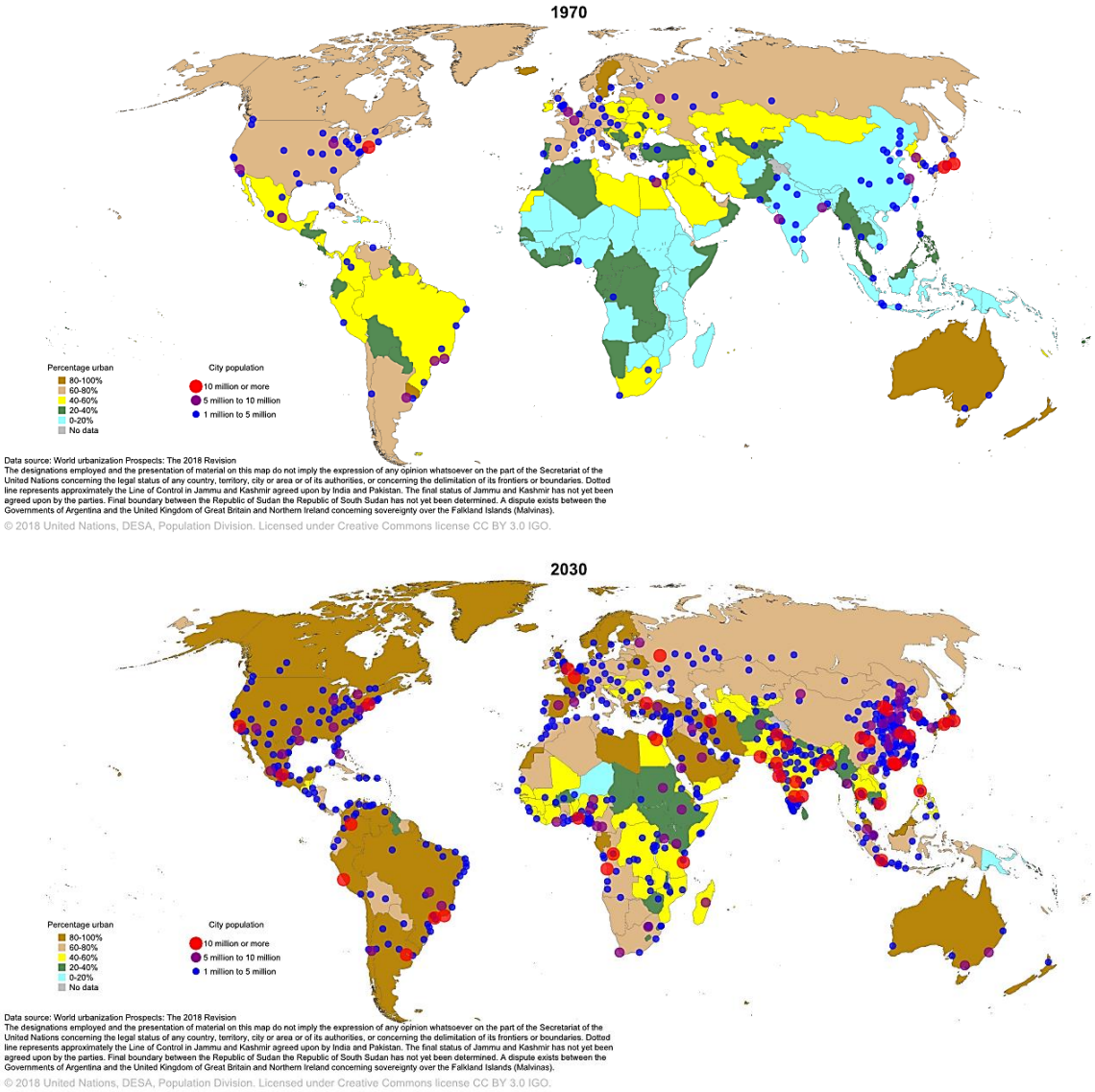

Figure 1. Population growth in cities – towards megacities.

Source: https://population.un.org/wup/Maps/, 26.09.2024.

The research procedure consisted of two stages. In the first one, a bibliometric analysis of the literature contained in the Scopus database was performed, which allowed to confirm the research gap. In the second stage, strategic documents of Polish voivodeship cities were reviewed. The analysis uses thematic modelling tools to find the dimensions of smart cities considered in the development strategies of Polish voivodeship cities.

2. The evolution of the smart city idea and the changing role of local administration

In today's dynamic and technologized world, the smart city concept holds the promise of a real improvement in the quality of life, entering the era of comfort and well-being of residents. This is confirmed by the spectacular metamorphosis that cities around the world have undergone over the past decades. From dusty streets and gray apartment blocks, cities have been transformed into sophisticated laboratories of innovation, quasi-organisms pulsating with the energy of digital life. However, this was not always the case. Technology did not at once become an ally to the inhabitants, and cities saturated with it, although impressive, often pushed people and their needs into the shadows.

The increase in popularity of the smart city concept has attracted the attention of not only business entities offering IT solutions, but also scientists, local government officials and residents. This has resulted in numerous definitions of smart city, which have made it possible to distinguish this concept from similar terms, such as information city (*information*), the digital city (*digital*) (Dameri, 2017) , the city of knowledge (*knowledge*). Some authors also refer to the community (*community*) (Albino et al., 2015), to highlight the importance of involving residents in collective efforts to improve the quality of life in the city.

The analysis of the set of definitions with the use of Keytool[1] has identified 28 main themes describing smart cities in the definitions, which can be arranged in 11 thematic groups relating to both real and postulative features of the city and its components, management of it and its resources, dimensions of its functioning, as well as the characteristics of its inhabitants. The whole set has been assigned to the category of texts on technology with a probability of p(a) = 0.9668374062 (see table 1).

Table 1.
Selected definitions of smart city

Author/year	The content of the definition of "*Smart city* is...":	Key Terms*
Gififnger et al., 2007	... A city that thinks ahead considers the priorities of the economy, environment, society, mobility, based on intelligent combinations of resources and self-determined activities, as well as using the potential of its residents. *Smart city* finds and implements smart solutions that allow us to improve the quality of life of residents and expand the offer of public services.	Smart CTY, Smart Solutions, Mobility (Text Class: Economy, P(A)=0.7172861099)

[1] Keytool is a tool provided by CLARIN-PL (https://services.clarin-pl.eu/services/keytool) with the help of which you can extract key phrases and proper names from the text. This is done using generative models and multi-label classification. The procedure of identifying keywords in the definitions contained in Table 1 was conducted using the interactive mode on two levels: individual definitions and the entire set of definitions. Keywords for individual definitions are included in the table, along with the probability of assigning these definitions to the indicated labels. The set identified for the entire set of definitions was used to interpret them under the table.

Cont. table 1.

Eger, 2009	… a smart community that consciously responds to the implementation of ICT as a catalyst in solving the problems of residents and economic entities. A smart city focuses on building and expanding infrastructure but attaches key importance to the creation of local identity and civic pride. Smart communities strive not only to implement new technologies, but to promote economic development, employment growth and to improve the quality of life in the city. Thus, the implementation of technology is not an end in itself, but only a way to generate benefits for the local community.	Smart city, local identity, smart communities, ICT, (text class: economy, p(a)=0.7030823231; energy, p(a)=0.8058710098, technology p(a) 0.9243766665)
Harrison et al., 2010	… a city that combines communication, social, business and IT infrastructure, in order to use the collective intelligence of the city.	City, Smart City, City Intelligence (text class: Energy, P(A)=0.609548986, Technology P(A) 0.7799118161)
Chen, 2010	… cities that use the communication and sensor capabilities built into the infrastructure to optimize the flow of energy and the flow of people and goods, supporting the daily life of residents, contributing to the quality of life in the city.	smart city, quality of life, city (text class: economy, p(a)=0.8640865088; energy, p(a)=0.971239686)
Caragliu et al., 2011	… investing in human and social capital as well as traditional (transport) and modern (ICT) communication infrastructure in order to support sustainable economic development with rational management of natural resources, through participatory management.	Participatory management, smart city, sustainable economic development (text class: economy, p(a)=0.546046257; transport, p(a)=0.8190048337; energy, p(a)=0.8299167156; technology p(a)=0.6137210131)
Komminos, 2011	… self-learning, innovative areas, using the creativity of their inhabitants and the knowledge of business entities, as well as digital infrastructure, facilitating communication and knowledge management.	Knowledge management, smart city, (text class: economy, p(a)=0.9912993312; technology p(a) 0.8076601624)
Guan, 2012	… A city that is prepared to provide the conditions for a healthy and happy community in the challenging conditions that global, environmental, economic and social trends may bring.	city, smart city, health, sustainable development (text class: ecology, p(a)=0.6235412955);
Barrionuevo et al., 2012	… a city that uses all available technologies and resources in an intelligent and coordinated way for economic development, respecting the principles of sustainable development and caring for the quality of life	Sustainability, Smart City (text class: Energy, P(A)=0.7566955686; Technology, P(A)=0.9623322487)
Lombardi et al., 2012	… a city that uses information and communication technologies to increase the interactivity and efficiency of urban infrastructure and its components, as well as to raise awareness among residents	Mobility, Smart City (Text Class: Technology, P(A)=0.7716469765)
Bakıcı, 2013	… an innovative city, rich in advanced technologies (high-tech) that connects people, information and all elements of the city in order to create a green, competitive city with a high quality of life	Eco-City, Smart City, Smart City (Text Class: Economy, P(A)=0.75703758; Technology P(A) 0.9712774754)

Cont. table 1.

Duckenfield, 2014	… A city that is pleasant to live in, work and socialize, which is networked, technologically connected and modern	City, Smart City, Livable City (text class: Technology, P(A)=0.5536438823)
Marsal-Llacuna et al., 2015	Cities that aim to improve the functioning of the entire urban area by using data, information and information technology (ICT) to provide more efficient services, monitor and optimize existing infrastructure, and increase cooperation between different stakeholder groups are innovative cities that are implementing new business models	innovative city, smart city, ICT (text class: economy, p(a)=0.9962778687)

Source: own elaboration based on: (Hall, Bowerman, Braverman, Taylor, Todosow, Von Wimmersperg, 2000. https://www.researchgate.net /publication/241977644_ The_vision_of_a_smart_city, [21.01.2021]; Giffinger, Fertner, Kramar, Kalasek, Pichler-Milanović, 2007; http://www.smart-cities.eu/download/smart_ cities_final_report.pdf [21.01.2021]; Eger, 2009; Harrison, Eckman, Hamilton, Hartswick, Kalagnanam, Paraszczak, Williams, 2010; Chen, 2010; Caragliu, Del Bo, Nijkamp, 2011; Komninos, 2011; Guan, 2012; Barrionuevo, Berrone, Ricart, 2012; Lombardi, Giordano, Farouh, Yousef, 2012; Bakıcı, Almirall, Wareham, 2013; Duckenfield, 2014; Marsal-Llacuna, Colomer-Llinàs, Meléndez-Frigola, 2015.

A constitutive feature of a smart city is the presence of modern technologies, which are to improve the quality of life (Bakıcı et al., 2013; Barrionuevo et al., 2012; Chen, 2010; Eger, 2009; Giffinger et al., 2007; Guan, 2012; Duckenfield, 2014), optimize resource use (Harrison et al., 2010; Lombardi et al., 2012; Marsal-Llacuna et al., 2015), sustainable development (Barrionuevo et al., 2012; Caragliu et al., 2009).

Smart city is a city that intelligently combines its resources (Giffinger, Fertner, Kramar, Meijers et al., 2007) including natural (Caragliu et al., 2009) and technological (Barrionuevo et al., 2012; Harrison et al., 2010), and optimizing urban infrastructure (Marsal-Llacuna et al., 2015) as well as the flows taking place in it (Chen, 2010). This requires the use of information and communication technologies (Eger, 2009; Lombardi et al., 2012) and their development (Caragliu et al., 2009) or to use information technologies (Bakıcı et al., 2013; Harrison et al., 2010), which bring together the components of the city and the people (Caretaker et al., 2013; Duckenfield, 2014). A smart city can also be determined by a smart community, which is sometimes treated as an object of investment (Caragliu et al., 2009), but much more often as a subject. The creativity of the inhabitants co-creates the innovation of the city (Caretaker et al., 2013; Komninos, 2011; Marsal-Llacuna et al., 2015) involved with the city administration in participatory city management (Caragliu et al., 2009) or knowledge management (Komninos, 2011). The authors differ in their approach to the smart city goal. Marsal-Llacuna sees it in strengthening stakeholder cooperation, Guan in the health and happiness of the city's community, and Lombardi only in increasing the awareness of residents while improving the efficiency of the city's infrastructure. Harrison shifts the focus from people to the use of city intelligence, which for Barrionuevo is a means to economic development (the actual goal of the smart city). For Caragliu, the economic development of the smart city must be sustainable, and for Caragliu, the Bakıcı Smart City is supposed to be ecological.

Synthetically speaking, the common feature is the use of IT and ICT to achieve the city's goals, although also in this case the emphasis can be placed on intelligent solutions (not necessarily technologies – (Barrionuevo et al., 2012)), traditional mobility infrastructure

or the social dimension of the (Guan, 2012). It is worth noting the advantage of understanding the essence of a smart city as a city that is an abstract system in which residents are only one of the components. Only Eger considers a smart community to be a constitutive element of a smart city, while Komninos considers it in an urban sense. In the urban system, the role of the decision-making and executive center is played by its administration, with a greater or lesser involvement of residents and other stakeholders to achieve the assumed goals. A review of the definitions reveals discrepancies in the approach to smart city goals (quality of life, health and happiness of residents, economic and sustainable development, green city, use of city intelligence, optimization of urban infrastructure, increased awareness of residents, closer cooperation of stakeholders). Other features of a smart city form a diverse catalogue, divergent in some dimensions (e.g., the role of the community), in others postulated (e.g., ensuring happiness). According to the quoted authors, a smart city is a city of knowledge, innovation and creativity, with a wide participation of residents in management, rationally using all available resources and technologies for sustainable, competitive economic development, integrating its stakeholders. From this point of view, the idea of a smart city integrates perspectives expressed in the concepts of a digital city, a smart city and a city of knowledge.

The constant evolution of cities, reflecting the changing needs of societies, technological progress and growing environmental awareness has led to a re-evaluation of the understanding of smart cities. As a result, we can distinguish four development phases (Generation of smart city, 2024); which at the same time can serve as a typology of cities due to their degree of implementation of the smart city idea:

1. Smart city 1.0 – covers a period of experimentation and fascination with new information and communication technologies that allow for an increase in the efficiency of the city's functioning. It is identified with sensors and software algorithms integrated into the urban fabric (Kitchin, 2014), where the city authorities adhere to the "must have" philosophy, i.e. a vision of the city of the future controlled and driven by the private sector, in which the relations and interactions between the city and its residents have been lost.
2. Smart city 2.0 – this is the phase in which data is becoming the new standard, and the development of Big Data technology and data analysis has allowed for a deeper understanding of urban dynamics and effective city management. The Internet of Things (IoT) has brought a new era of real-time monitoring and management of city infrastructure, opening the door to endless possibilities for administrations to refine and improve the quality of life for residents. To avoid the risk of dehumanization of technology-oriented cities, the future of cities requires cooperation between local authorities and residents (Robinson, 2015). Only this synergy makes cities truly intelligent, becoming a source of inspiration and fascinating perspectives for urban development (Szołtysek, 2019).

3. Smart city 3.0 is a period of integration of various systems and services. Cities have moved from implementing siloed solutions to developing cohesive, human-centric ecosystems where residents actively take part in society and decide on the future of cities. In this phase, macroeconomic measures of the city's development lose their importance in favor of others that describe the quality of life in the city, such as creativity, innovation, democracy, a sense of happiness, the degree of acceptance by the environment or satisfaction with living in a given city (Montgomery, 2015, p. 129). Smart city 3.0 means a return to the human dimension of the city, aimed at building a civil society (Gehl, 2014, p. 3).
4. Smart city 4.0 – the latest version of the cities of the future, in which innovation is not the goal, but a means of its implementation. The logic of the city authorities and – to a greater or lesser extent – its inhabitants is dominated by the pursuit of sustainable development goals (the so-called UN Millennium Goals) and the involvement of residents in the active creation of solutions. Smart city 4.0 sets the boundary between traditional cities and the future of integrated and innovative communities. It is a vision of a city where technology becomes the foundation on which to build an improvement in the quality of life, social well-being and happiness of its residents. A challenge that may hinder the further development of this concept – at least in Europe – is still the issue of the energy needs of cities that are massively adopting ICT.

Since smart cities cover all areas of life, it is often treated as a panacea for city problems. In this spirit, solutions based on the use of modern technologies are already implemented in Smart City 1.0 in the area of the "pain" of a given urban center (and especially its business stakeholders): communication, pollution or optimization of urban management (Galati, 2017), especially in the context of mobility and infrastructure. In this regard, researchers from the Vienna University of Technology (see also: Lee et al., 2013) They identified six basic dimensions of a smart city: smart mobility, smart economy, smart environment, smart people, smart governance and smart living[2] . This holistic approach enables city authorities to consider all relevant functional aspects of the city in their ongoing response to emerging challenges as well as in their long-term planning. The degree and manner of their inclusion in the strategic documents of cities allows us to conclude about the level of implementation of the smart city concept in them.

In the era of dynamic development of cities and the increase in the number of their inhabitants, the concept of smart city should become a key element of the development strategy of urban centers. The strategy allows you to outline the directions of the city's development and respond appropriately to changes in its surroundings. Without entering into the definitional discourse on development strategy, we will assume that it is a system of medium- and long-

[2] As Galati points out, the smart city is still more of a vision of the future than a reality. He justifies his judgment by the lack of any example of cities in which all dimensions would be realized (Galati, 2017).

term frameworks of activity, setting the directions of development. In other words, it is a well-thought-out concept of action, thanks to which the city, considered by analogy as an organization, generates a competitive advantage – to attract new (desirable) groups of residents, business entities, investments. The implementation of the strategy results in a diverse level of economic development and quality of life in the city. Although the attractiveness of a city is affected by its resources and the potential for their best use, the strategy is a sine non condition for effective management of resources and potential. Formulating urban development strategies is the domain of local authorities, which in their pursuit of implementing the idea of smart city can be supported by local, national and EU authorities.

The concept of a smart city is directly in line with the EU's goals related to the European Green Deal. They impose on local governments the obligation to create strategies to reduce CO2 emissions, improve energy efficiency and promote sustainable transport. According to Article 174 of the Treaty on the Functioning of the European Union (TFEU), cities are obliged to pursue a cohesion policy that aims to reduce disparities in the development of regions, including the implementation of innovative urban solutions following the principles of sustainable development. In this context, European legislation, such as Regulation (EU) 2021/1058 of the European Parliament and of the Council on the European Regional Development Fund and the Cohesion Fund, stimulates the development of smart cities by funding innovative projects and supporting integrated approaches to urban space management. Also, the Regulation (EU) 2021/1060 of the European Parliament and of the Council sets up rules on the use of structural funds, obliging local governments to develop territorial strategies that combine smart city goals with regional and local priorities.

In addition, the Urban Agenda for the EU, as a voluntary initiative of cooperation between cities and EU institutions, promotes the implementation of smart city solutions that integrate sustainable development with digital technologies, transport and energy efficiency. Strategic planning at local and regional level, supported by instruments such as Integrated Territorial Investments (ITI), is therefore crucial for the success of urban development policy.

Development strategies that consider the assumptions of smart cities allow cities not only to respond more effectively to the challenges of a growing population and environmental problems, but also increase their investment attractiveness and competitiveness in the international arena. The introduction of smart solutions makes it easier to meet the expectations of residents as well as obligations towards European legislation. Local governments that effectively integrate smart city assumptions into their strategies have the opportunity to use EU funds, while improving the quality of life and promoting sustainable urban development.

In recent years, the concept of smart cities has been gaining popularity all over the world. It is based on the use of modern technologies to improve the daily lives of residents and improve the operation of cities. Importantly, this is no longer just a priority for major metropolises such as London, New York and Tokyo. More smaller cities also see the potential in these solutions, introducing intelligent transport, energy or waste management systems. Also in Poland, cities

are beginning to implement the smart city concept, which allows them not only to keep up with global trends, but also to better respond to the needs of residents and challenges related to the development of urban infrastructure. The choice of Polish voivodeship cities as the subject of research on the scope of implementation of the smart city idea in strategic documents is justified for many reasons:

1. Poland, which is one of the leaders in Central and Eastern Europe in terms of urban development, began to integrate the idea of smart city in urban development strategies relatively early. In particular, voivodeship cities, as the largest and most important administrative, economic and cultural centers, play a key role in the formulation and implementation of sustainable development policies and the implementation of modern technologies in urban space management.
2. Voivodeship cities in Poland function as central regional points, which means that not only their own development, but also the development of entire regions depends on their ability to innovate. As the main decision-making centers, these cities have the largest financial, administrative and intellectual resources, which makes them natural leaders in the implementation of smart city strategies. Investments in digitalization, intelligent transport systems, sustainable environmental management and innovative public services contribute to improving the quality of life of citizens and increasing the operational efficiency of cities;
3. Polish voivodeship cities are diverse in terms of scale, nature and challenges, which makes it possible to analyze their strategies from different perspectives. Cities such as Warsaw, Krakow, Wroclaw and Poznań, which are metropolises with high economic potential and strong international ties, are implementing smart city projects in a more advanced way, integrating technologies in various areas – from urban mobility to the digitization of public services. On the other hand, smaller voivodeship cities, such as Rzeszów, Opole or Zielona Góra, have unique challenges related to limited resources, but also innovative approaches to local problems, which makes them interesting examples for analyzing the effectiveness of implemented smart city solutions.
4. Voivodeship cities are often beneficiaries of European programs that support the development of smart cities. Thanks to European Union financial programs, such as Horizon 2020, the European Regional Development Fund (ERDF) or the National Recovery Plan, these cities have access to funds for the implementation of projects related to digitization, environmental protection, transport and social innovation. Examples include: the "Smart City Warsaw" Project, the "Integrated Public Transport System" for the City of Krakow, "ITS Wrocław", "Smart City: Gdańsk", the "City Hub Łódź" Project, the "Smart Rzeszów" Project.

Finally, the choice of voivodeship cities makes it possible to compare their development with other European urban centers that include the idea of smart city in development strategies. Polish cities are becoming part of global urban trends, and their development in this area is increasingly noticed in international rankings, such as the IMD Smart City Index – an assessment of the city in terms of innovation, digitization and sustainable development; IESE Cities in Motion Index – evaluates cities in terms of technology, mobility, environment and governance, or Global Smart City Index – evaluates cities in terms of smart city strategy, infrastructure and implemented projects (cf. Table 1).

Table 2.
The place of Polish cities in smart city rankings

Ranking / City	IMD Smart City Index				IESE Cities in Motion Index				Global Smart City Index			
	year				year				year			
	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023
Warsaw	75	75	69	63	83	83	77	73	55	55	50	47
Cracow	88	88	82	79	108	108	102	98	N/A	N/A	N/A	N/A
Wroclaw	85	85	80	76	90	90	85	81	60	60	55	51
Gdansk	95	95	89	85	105	105	99	94	95	95	89	85
Poznan	N/A	105	98	93	110	110	105	100	115	115	110	105
Boat	103	103	98	83	120	120	115	110	115	115	108	102
Rzeszow	N/A	N/A	N/A	120	N/A	N/A	N/A	130	N/A	N/A	N/A	125
Katowice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	115
Szczecin	N/A	N/A	N/A	N/A	N/A	N/A	130	125	N/A	N/A	N/A	N/A

Source: In-house analysis based on: IMD Smart City Index, IESE Cities in Motion Index, Global Smart City Index.

The analysis of the position of Polish voivodeship cities in the context of these rankings allows us to assess their progress and shows a systematic improvement in positions. And this emphasizes their dynamic development and increasing competitiveness against the international background.

3. Methods

Since, despite the growing interest in the concept of smart city, there is still a noticeable deficit of publications in the literature that comprehensively combine urban development strategies with the idea of smart city, it is planned to carry out a bibliometric analysis of the literature to confirm it[3] available in the Scopus database, in accordance with the principles adopted in this type of research (Orłowska et al., 2017). On the other hand, in order to identify the degree of implementation of the smart city idea in the currently applicable strategies of regional capitals (on the example of Polish voivodeship capitals), we analyzed them using NLP

[3] The purpose of this study is not to make a systematic review of the literature, but only to indicate the deficit of scientific publications in this area.

tools (thematic modeling), paying particular attention to morphosyntactic relationships related to the concept of smart city. At the beginning of the bibliometric analysis, we formulated the following research questions – To what extent does the scientific literature take into account the links between urban development strategies and the implementation of the smart city concept, and what are the main areas of research concerning the implementation of the smart city idea in urban development strategies?

Scientific articles from the last ten years were used to develop the review. The research was conducted in September 2024. The following keywords were used at the search stage: *smart city*, *city strategy* and *strategy city planning*. This allowed us to extract 130 publications on smart cities in connection with urban development strategies in the Scopus database.

In order to implement the second strand of the study, an analysis of strategic documents was conducted to find whether local government units fully integrate modern technological and digital solutions in their development plans, and which of these solutions are considered key for individual cities. In particular, they were interested in how individual voivodeship cities treat smart city assumptions in the context of their unique challenges and resources.

To achieve our goal, we were looking for an answer to the question of what specific technologies and digital solutions are considered to be priorities in cities and to what extent individual local government units implement the full spectrum of smart solutions, corresponding to all dimensions of smart city.

The study used thematic modelling tools to find the main themes that fit into the six main dimensions of smart city, as defined by the Technical University of Vienna: smart economy, smart mobility, smart environment, smart people, smart living and smart governance. The strategies of voivodeship cities were examined in terms of the presence of individual dimensions of smart city in their records using NLP (Natural Language Processing) tools, including the extraction of information from texts (Topic). The research procedure consisted of four stages (see figure 2).

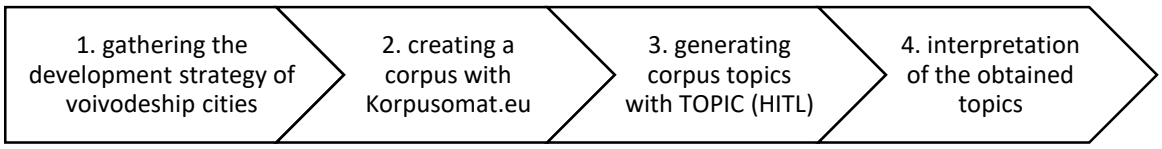

Figure 2. The research procedure.

Source: own work.

The first stage consisted in collecting strategic documents of all voivodeship capitals. The strategies were obtained from the official websites of voivodeship cities in the form of pdf documents. Their further processing and analysis were conducted using applications and services available on the CLARIN-PL platform. In the next stage, the documents were

transformed into a lexical corpus with strategies of voivodeship cities using the Korpusomat.eu application[4].

To extract topics (topics), the Topic HITL application using the LDA algorithm was used[5]. This allowed them to find the coexisting words that make up a given topic. In the course of next reviews of the results, the stop list was supplemented (up to the level of 6326 items) and the number of topics (3, 12, 100, 18, 50, 30, 20) and the level of the λ parameter (0-1) were changed. The interactive nature of Topic HITL allows for online analysis of the obtained results and their modification in next rounds of calculations based on data illustrated with a map of distances between topics and an integrated bar chart. The final results of the analysis are presented in the form of a map of the distances between the topics (see Fig. 3) and – for practical reasons – in a table including the numbers and names of topics assigned to the cities that occurred in a given topic (Table 5). Figure 3 illustrates both parameters for Lublin, as the first city whose name appears on the list of the most important (salient) terms of the entire corpus. "Lublin" is part of the topics (in descending order of relevance of this term, shown by the size of the fields on the map) numbered 15, 1, 12.

The size of the fields illustrating topics on the map depends on their share in the corpus (the marginal distribution of the topic based on *the distinctiveness* and *relevance of* the words in it), while the selection of a word from the bar chart allows you to see the conditional distribution of this term in the topics in which it occurs on the map. This allows for a quick assessment of the distinctiveness of a word (few topics in which it occurs) and its appropriateness in relation to a given topic (the size of the field on the map).

[4] Korpusomat.eu is a free platform that is an extension of the Polish version of the CLARIN-PL.eu project, which allows you to create and process text corpora. The input document is transformed into a multi-layered (with the help of two high-level programming libraries for natural language processing, spaCy and Stanza) corpus of texts, which can then be analyzed in morphosyntactic terms. The conversion of input files is based on the Universal Dependencies (UD) scheme allowing for consistent cross-language annotation, Karol Saputa, Aleksandra Tomaszewska, Natalia Zawadzka-Paluektau, Witold Kieraś, and Łukasz Kobyliński. Korpusomat.eu: A multilingual platform for building and analyzing linguistic corpora. In Jiří Mikyška, Clélia de Mulatier, Maciej Paszynski, Valeria V. Krzhizhanovskaya, Jack J. Dongarra, and Peter M.A. Sloot, editors, Computational Science – ICCS 2023. 23rd International Conference, Prague, Czech Republic, July 3–5, 2023, Proceedings, Part II, number 14074 in Lecture Notes in Computer Science, pp. 230-237, Cham, 2023. Springer Nature Switzerland. Source: https://korpusomat-eu.readthedocs.io/pl/latest/manual/preferences.html, 21.11.2024.

[5] The Latent Dirichlet Allocation (LDA) method is used to identify hidden topics as polynomial probability distributions for terms that occur in a corpus dictionary (word list) (Sievert, Shirley, 2014). The method assumes that the corpus is a collection of texts that are 'bags of words', and each text can consist of many topics (https://www.ibm.com/topics/latent-dirichlet-allocation#f01). For a given corpus, (1) a model of the coexistence of words in a given fragment (text) and in the entire corpus is determined, and (2) the probabilities of the occurrence of individual words in a random topic to which a given text has been assigned (the same text to many topics) are calculated. On the basis of the calculated probability of the occurrence of a word in a given topic, the content of the topics is determined (fuzzy grouping – *fuzzy clustering*, https://wiki.clarin-pl.eu/pl/nlpservices/list/topic3). This is done by using Gibbs sampling in successive iterations of the calculation (100 iterations are set in the CLARIN solution), allowing the result to be gradually sharpened (Murel, Kavlakoglu, What is Latent Dirichlet allocation, 4.22.2024, https://www.ibm.com/topics/latent-dirichlet-allocation#f01, 23.11.2024. Assigning words (terms) to topics also means assigning texts in which the terms occur to them.

The selected topics are additionally illustrated in the form of the so-called word cloud, which show the immersion of terms in relation to other terms belonging to a given topic and text in a multidimensional space (up to a maximum of 1000 dimensions). With a sufficiently large number of segments in the corpus (> 1 million), the results obtained allow us to find hidden connections in the corpus texts and assign them to significant topics. Their interpretation requires the participation of a researcher who deciphers the meaning resulting from the word cloud and from the list of the most important words (bar chart).

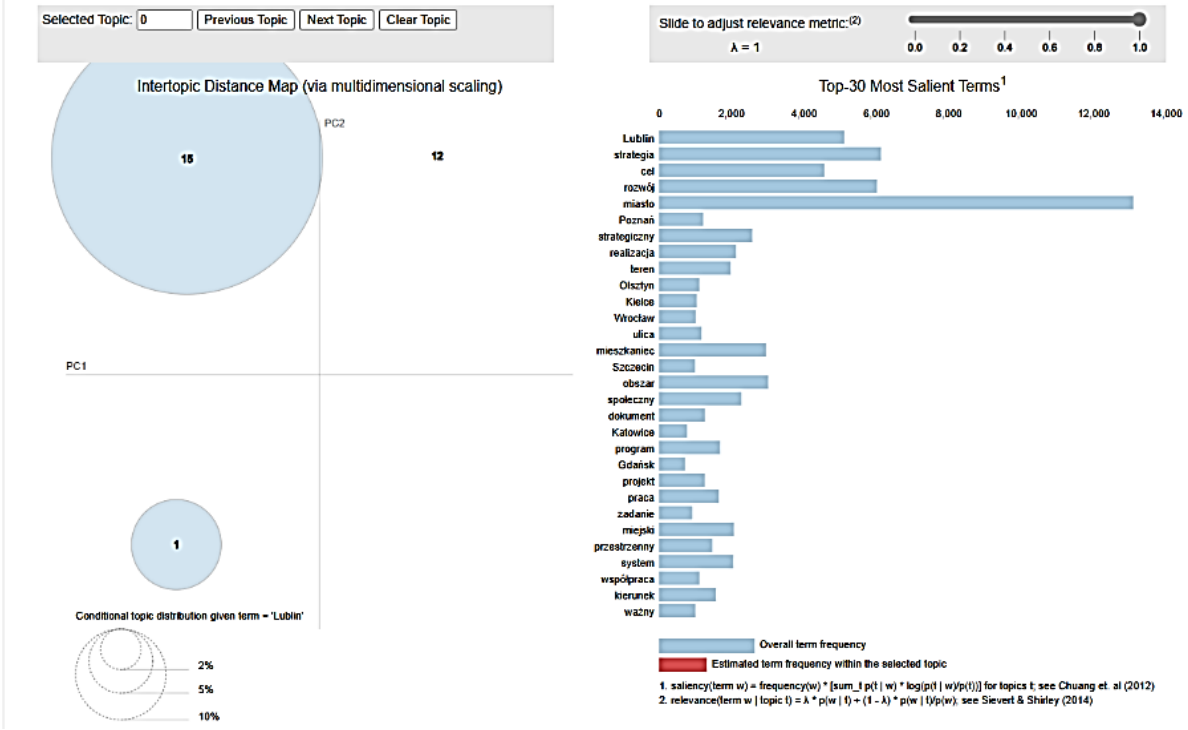

Figure 3. Visualized results of thematic modeling for a selected term in an iteration with twenty topics. ***Left***: A distance map between topics with multidimensional scaling of the due date position relative to PC1 and PC2. ***Right***: a bar graph of the thirty most important terms for the entire corpus.

Source: own study.

4. Results

4.1. Smart city in the context of urban development strategies – results of the literature review

A literature review shows that there is a distraction among researchers who focus on particular aspects of smart cities, such as technology and sustainable transport, but there is no holistic approach that integrates these elements into the strategic planning of cities. The deficit of studies analyzing in detail the links between urban development strategies and the implementation of the smart city concept is confirmed by the results of a bibliometric analysis of the literature available in the Scopus database, following the principles adopted in this type

of research. The answer to the questions about the degree of consideration in the scientific literature of the links between urban development strategies and the implementation of the smart city concept, as well as about the main areas of research concerning the implementation of the smart city idea in urban development strategies, allowed to distinguish in the collected collection of scientific texts (130 items) the following groups of publications concerning:

1. Theoretical framework of urban development and its connections with the idea of smart city (Albino et al., 2015; Bolici, Mora, 2015; Ders, 2016; Mora et al., 2017).
2. Case studies of cities that integrated smart city concepts with urban planning (Batty, 2018; Hu, 2019; Mancebo, 2020; Tranos, Gertner, 2012).
3. Urban policies and regulations supporting sustainable urban development, including smart technologies (Barber, 2013; Lange, Knieling, 2020; March Yun, Lee, 2019).
4. Various aspects of smart city implementation, such as technologies (IoT, Big Data, AI), urban infrastructure management, digitization of public services (Caragliu et al., 2009; Chourabi et al., 2012; Naphade et al., 2011; Zhang et al., 2020).
5. Examples of the implementation of the smart city idea in the context of urban development policy at the local, regional and global level (Dameri, 2017; Hu, 2019; Lange, Knieling, 2020; Paskaleva, 2011).

Although the number of publications shows an upward trend in 2015-2024, their number is still relatively low (see figure 4). This shows the disproportionality to the needs resulting from increasing urbanization and the requirements of sustainable development, and at the same time signals the need to increase the intensity of research on smart city development strategies. This area has great potential to bring real benefits to the cities of the future.

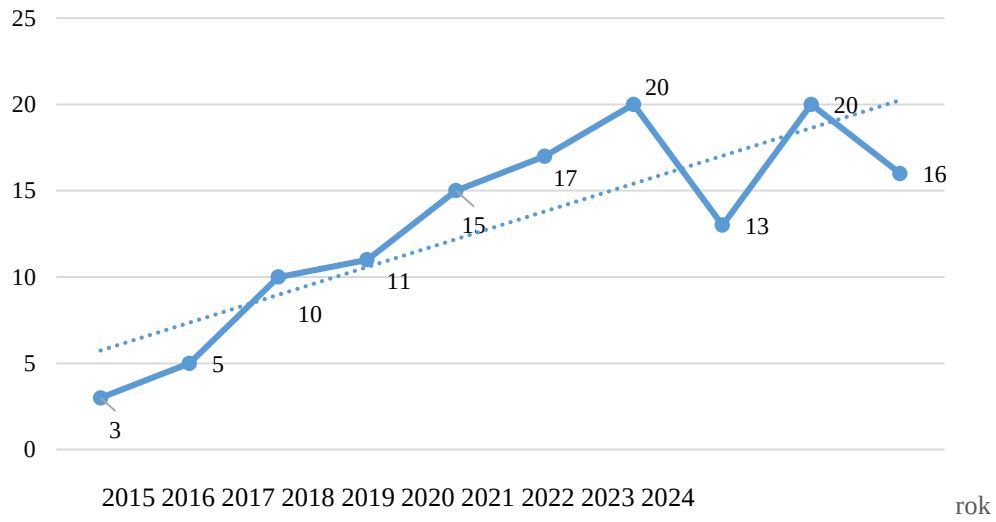

Figure 4. Number of publications on smart city issues in the context of urban development strategies. Source: based on Scopus.com.

Considering the country of publication, there is a significant heterogeneity of literature, with all continents been in the list (in the figure except South America). A total of forty-three countries were found, from which the authors addressed the issue of implementing the idea of smart city in strategic documents as shown on Figure 5.

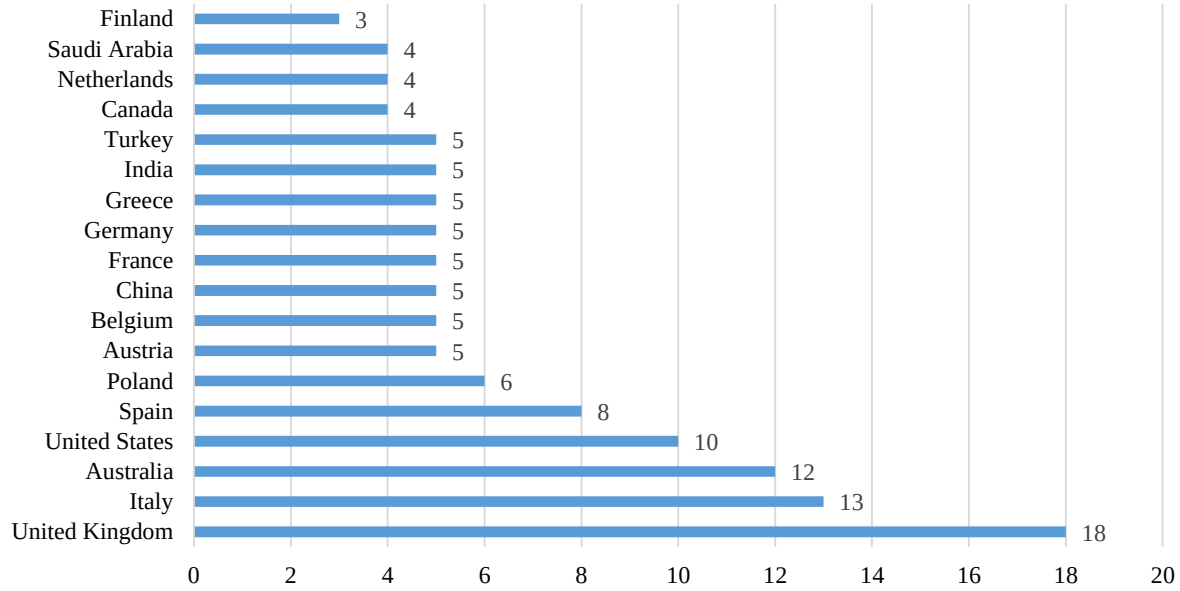

Figure 5. Number of publications by country.

Source based on: Scopus.com.

In the case of multi-author texts, the publication was assigned to the country of the first author, which resulted in the concentration of articles in the United Kingdom (18), Italy (13), and then in Australia (12), the United States (10), Spain (8) and Poland (6). The distribution of publications on smart cities and urban development strategies reflects the level of advancement and scale of implemented urban initiatives. Leading the way are countries such as the United Kingdom, Italy, Australia and the United States, which are investing heavily in the development of smart city technologies. London, Milan and Melbourne are the cities that have become pioneers of intelligent energy, transport and public space management systems. Their projects, such as the "Smart City Plan" in Australia or the "Smart Columbus" in the USA, stimulate academic research, which is reflected in scientific publications. Interestingly, a relatively large number of publications come from Polish, where the implementation of the smart city concept is still in the development phase, and Polish cities are not leaders in smart city rankings. Nevertheless, cities such as m.in. Gdańsk, Warsaw and Wrocław can boast of programs for the implementation of intelligent transport systems or energy and water management.

A large diversity was also noted in the context of assigning publications to scientific disciplines (see fig. 6). It is not surprising that publications in the field of social sciences prevail (91). The development of smart cities is undoubtedly an area strongly related to public management, urban policy, urban planning and interactions between people and technology. Smart cities are not only about technology, but above all about changing the functioning of

cities and communities. The second place was taken by technical sciences (37 publications), which emphasizes the technological and infrastructural side of smart city implementation.

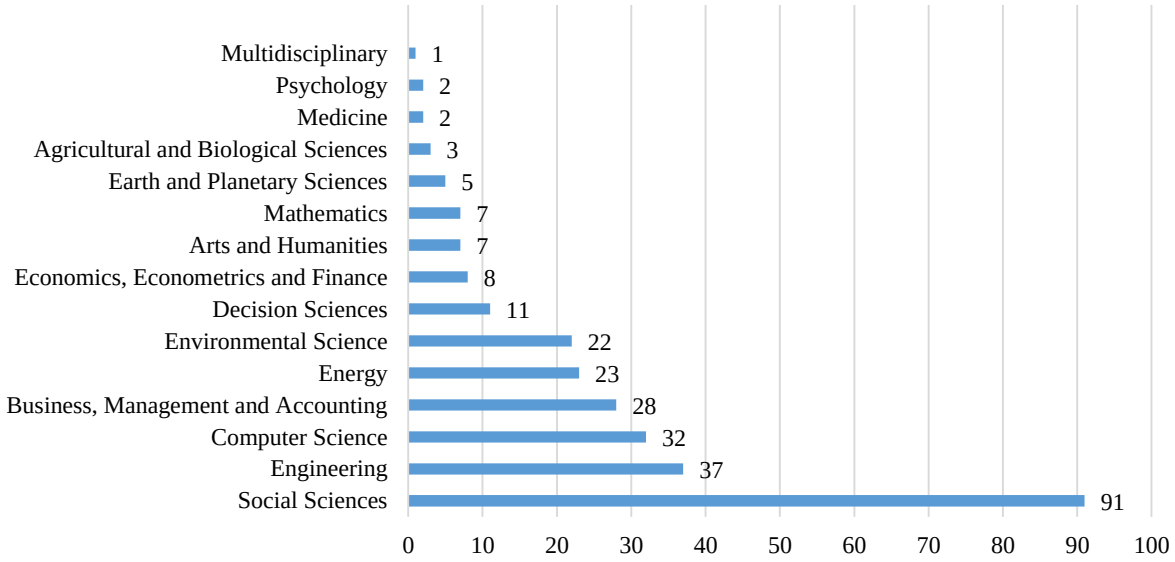

Figure 6. Number of publications by research area.

Source based on: Scopus.com.

Engineers are key in developing intelligent transportation, energy, water, and other aspects of urban infrastructure. It is no different in the case of computer scientists, which so leads to a significant number of publications (32) assigned to this research area. Smart cities are based on modern IT systems, such as IoT (Internet of Things), big data or artificial intelligence, which enable data collection, analysis and optimization of city management. Management sciences (28 publications) and energy sciences (23 publications) occupy an equally important place, as smart cities are designed with sustainable management of energy resources in mind, and effective business models are necessary for financing and implementing these technologies. Environmental sciences also play an important role – smart cities focus on sustainable development and minimizing the negative impact of cities on the environment through CO2 emission management, waste and sustainable water management.

The institutional perspective (see fig. 7) reveals the main sponsors of research on the idea of smart cities and regional development. Of these, the European Commission is at the forefront, m.in through the Horizon 2020 program and the European Regional Development Fund (ERDF). This reflects the Commission's efforts to implement the concept of sustainable smart growth in the cities of the EU Member States, in response to the challenges of urbanization and climate change. Through Horizon 2020, investments were made in innovations that improve the quality of life and at the same time develop model models of cities of the future. They would be based on the potential of digital technologies, artificial intelligence and the Internet of Things (IoT), but in connection with social and environmental policy. Thanks to this formula, cities would become more efficient, resident-friendly (inclusive) and ecological, and thus more resilient to climate change.

In the next stage, the material was selected in terms of the quality of the presented research – all abstracts and keywords were analyzed. This activity was used to select publications on the basis of which attempts were made to find the main areas of research related to the implementation of the smart city idea in urban development strategies. All those articles in which the issue of the strategy was only a contribution were rejected.

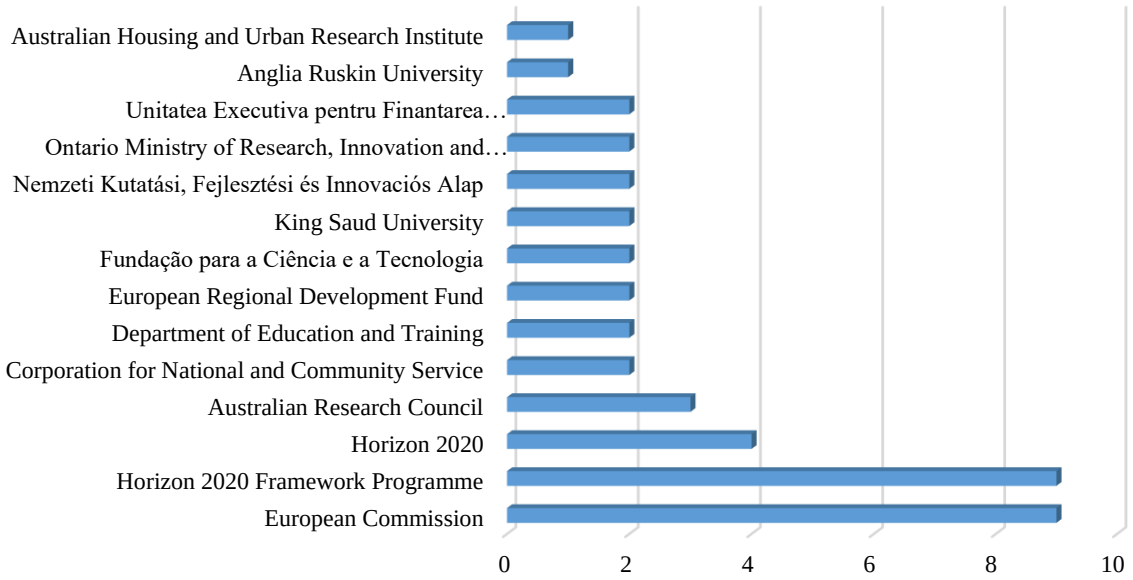

Figure 7. Number of publications by Funding Institution.

Source based on: Scopus.com.

A detailed analysis of the texts, which included thirty-five articles, leads to the conclusion that the idea of a smart city is a holistic approach to solving the problems of modern cities and responds to the needs of their residents. In scientific literature, numerous key areas of research are distinguished, showing the complexity and multifaceted implementation of the smart city idea in urban development strategies. The included publications distinguish areas that correspond to the dimensions of smart cities proposed in the previously cited report of the University of Vienna. Technology and infrastructure are at the forefront, followed by sustainability and the environment, followed by urban governance and social innovation, and research into social inclusion and quality of life. A separate thread related to modern technologies turns out to be the subject of safety in the city and management of intelligent buildings. Finally, the area of research focusing on the challenges related to the management and implementation of smart city strategies in cities should also be mentioned. A discussion on the detailed arrangements for each of the identified areas will be presented in the last point.

4.2. The scope of implementation of the smart city idea in city strategies – the perspective of Polish voivodeship cities

In the field of analysis of the strategy of voivodeship cities, it covered the corps built of transformed strategic documents. At this stage, the corpus query function was used to detect occurrences of the phrase "smart city" (corpus search formula: [orth="(smart)"] [upos="(NOUN)" & orth="c.*"] - 71 occurrences in the noun form were detected, 11 of which were repetitions. The function of finding the word profile for the lemma "smart" and its connection with other corpus concepts (collocations) was also used. The presence of the concept of "smart city" in strategic documents of Polish voivodeship cities is confirmed by the occurrence of the terms smart and city (with the lemma "cit" 49 times) in the form of a multi-word expression (Table 3).

Table 3.
Collocations of the word "smart" in the noun form detected in the corpus under study

Nature of the speech	The word with which "smart" is used in coordination	Adjective modifiers of the word "smart"	Nominal modifiers of the word "smart"	Words whose modifier is "smart"	Prepositions "smart"	Words with which "smart" creates multi-word expressions
Co-occurring words in relation to "smart" (frequency of occurrence in the corpus)	• Linkage (8.404) • Economy (7.072) • Environment (6.654)	• CIT (8.878)	• CIT (11,685) • create (8.678)	• Idea (9.917) • concept (9.356) • build (9.188) • Solution (8.039) • conditions (7.745) • area (6.062) • city (4.672)	• in (4.096)	• CIT (12,907) • mobilit (10.023) • living (10.023) • Economa (9.978) • environme nt (9.642)

Source: own work based on https://korpusomat.eu/word_profiles/3717/, 21.11.2024.

A detailed review of the detected collocations (word combinations here: in the studied corpus) reveals the following properties of the studied strategies of voivodeship cities:

- In terms of form, they are very diverse: stylistically, the volume of the text, the time of its creation (the earliest: in 2011, the latest in 2023) and the way it was designed, as a result – despite the common threads and solutions resulting from the similarity of the features and role of the strategic object, each of the strategies is a separate and specific record of the plans of the authorities of a specific city;
- The creators of the city strategy are aware of the importance and potential of the Smart City concept for their centers, as showed by its reference in documents directly or in the form of a Polish translation (smart city);
- The word smart appears in strategies in multi-word expressions "smart city" (49 co-occurrences), smart mobility (4 co-occurrences), smart living (4), smart economy (4), smart environment (3) which shows the scope of implementation of the concept;

- Smart City occurs eight times in strategies in a prepositional phrase such as "towards" – signaling that it is the target point of the strategy, or "in the area", which is combined in the studied set with a description of the solutions already implemented;
- Smart city is named in strategies as an idea (9 times) or a concept (5 times) that brings with it certain solutions (4 presentations), or is used to build the image of the city (5) or create good living conditions in it (8);
- Finally, smart cities coexist with the category of functional connections in space (4), economy (4), and the environment (3 times).

In response to the question about the degree and scope of implementation of the smart city concept, one may be tempted to point out that this idea is present in the strategies of Polish cities, but rather as a promising direction for improving selected areas of the city's functioning than a comprehensively implemented concept of its transformation. The only exception is Lublin, for which the current strategy directly provides for the continuation of the implementation of the smart city idea started in the earlier strategic period. Some cities, on the other hand, focus on sustainable, innovative, multidimensional (Katowice) or "wise" (Wrocław) development, which is shown in Table 4 as an expression of the city's strategic self-identification. Although these are mutually consistent approaches, the choice of any of them can be interpreted either as a manifestation of distance from the latest global trends in the development of cities, or as an attempt to continue the previously chosen development trajectory, better suited to the identified challenges and potentials of a given city. A solution in this regard will require further research using questionnaires.

The processed corpus consists of fifty-five documents in .txt,. json and .conllu formats, along with a .xlsx frequency list, which were then subjected to thematic modeling (Walkowiak, Gniewkowski, 2020), using the Topic HITL application[6] made available by CLARIN.PL[7]. The corpus consists of 554013 segments, and the frequency list consists of 25971 lemmas with a frequency of occurrence from 55003 to 1, with the most frequent occurrence being a dot (punctuation mark).

[6] Topic HITL (Human-in-the-Loop) allows for automatic extraction of information about topics covered in the texts of the corpus being processed. For this purpose, text processing methods appropriate for each stage of thematic modeling are used: 1. Dividing excessively long texts into fragments (max. 20,000 characters), 2. segmentation of texts into sentences, identification of grammatical classes and lemmatization (tool: postagger), 3. generation of topics in graphic form. The researcher has an impact on the preparation of the input data (corpus cleaning, parameterization of the lists of words taken into account – the so-called start list and those not included in the modeling – the so-called stop list), the selection of modeling parameters: the number of topics (4-100), the method of their extraction (LDA, Bertopic), the level of the significance measure ($\lambda \in \{0,1\}$). The method generates results in the form of a graphical intertopic distances map based on the marginal distribution of topics between PC1 (first principal component) and PC2 (second PC), a bar graph with the most appropriate words for the selected topic against the frequency of occurrence of the word in the entire corpus, and a cloud of words illustrating the topic. https://wiki.clarin-pl.eu/pl/nlpservices/list/topic3

[7] https://services.clarin-pl.eu/

Table 4.
The degree to which the dimensions of the "smart city" concept are considered in the strategies of Polish voivodeship cities

City	Year of adoption of the strategy	Dimensions of the "smart city" concept						Self-identification of the city in the strategy
		mobility	environment	economy	people	living	governance	
Bialystok	2022	v	v	v	v	v	v	Smart
Bydgoszcz	2020	(v)	(v)	(v)		(v)	(v)	Sustainable
Gdansk	2022	(v)	(v)		(v)	(v)		Compact
Gorzów Wielkopolski	2021	(v)	(v)	(v)	(v)	(v)	(v)	Sustainable, for generations
Katowice	2016	(v)		(v)	(v)	(v)		Smart
Kielce	2021	v	(v)	(v)	(v)	(v)	v	Compact, smart
Cracow	2018	v	v	v	v	v	v	Smart
Lublin	2022	(v)	(v)	(v)	(v)	(v)	v	Smart 3.0
Boat	2021	(v)	(v)	(v)	(v)	(v)	(v)	Creative
Olsztyn	2022		(v)	(v)			(v)	Smart City 3.0
Opole	2019					(v)	(v)	Smart
Poznan	2017	(v)	(v)	(v)	(v)	(v)	(v)	Smart
Rzeszow	2015		(v)	(v)	(v)	(v)	(v)	Smart
Szczecin	2011			(v)		(v)		Innovative
Torun	2018	(v)	(v)	(v)	(v)			Smart
Warsaw	2018	(v)					(v)	Digital city, compact metropolis
Wroclaw	2018	(v)	(v)	(v)		(v)		Sustainable, smart
Zielona Góra	2023			(v)	(v)		(v)	University

( ) means that a given dimension has been included in the strategy, but with a different modifier than "smart", e.g., smart, innovative, sustainable, ecological, creative.

Source: own study based on current city strategies.

To extract topics, the Topic HITL application including the LDA algorithm was used[8]. This allowed us to find the coexisting words that make up a given topic. In the course of next reviews of the results, the stop list was supplemented (up to the level of 6326 items) and the number of topics (3, 12, 100, 18, 50, 30, 20) and the level of the λ parameter (0-1) were changed. The interactive nature of Topic HITL allows for online analysis of the obtained results and their modification in next rounds of calculations based on data illustrated with a map of distances between topics and an integrated bar chart as shown on Figure 3. The table 5 includes the numbers and names of topics assigned to the cities that occurred in a given topic.

The topic names in Table 5 reflect the key terms they include, based on the calculation of the saliency and relevance measures – the equations are given in Figure 3.

[8] The Latent Dirichlet Allocation (LDA) method is used to identify hidden topics as polynomial probability distributions for terms that occur in a corpus dictionary (word list) (Sievert, Shirley, 2014). The method assumes that the corpus is a collection of texts that are 'bags of words', and each text can consist of many topics (https://www.ibm.com/topics/latent-dirichlet-allocation#f01). For a given corpus, (1) a model of the coexistence of words in a given fragment (text) and in the entire corpus is determined, and (2) the probabilities of the occurrence of individual words in a random topic to which a given text has been assigned (the same text to many topics) are calculated. On the basis of the calculated probability of the occurrence of a word in a given topic, the content of the topics is determined (fuzzy grouping – *fuzzy clustering* https://wiki.clarin-pl.eu/pl/nlpservices/list/topic3). This is done by using Gibbs sampling in successive iterations of the calculation (100 iterations are set in the CLARIN solution), allowing the result to be gradually sharpened (Murel, Kavlakoglu, What is Latent Dirichlet allocation, 4.22.2024, https://www.ibm.com/topics/latent-dirichlet-allocation#f01, 23.11.2024). Assigning words (terms) to topics also means assigning texts in which the terms occur to them.

Table 5.
Main topics reflecting the provisions of the strategy of Polish voivodeship cities

No	Topic name	A city whose name is among the 30-most relevant terms for topic
0	Top 30 most salient terms	Gdansk, Katowice, Kielce, Lublin, Olsztyn, Poznań, Szczecin, Wrocław
1.	Urban components and spatial planning	Lublin
2.	Strategic growth dimension	Wroclaw
3.	Strategic process	
4.	Items and functions of urban space	
5.	City habitant is important	Opole!, Poznan, Katowice
6.	Activities focused on habitant	Wroclaw
7.	Focus on best place to settle	Bydgoszcz
8.	Business and academy cooperation	Lublin
9.	Programming documents for city space planning	
10.	City of degrees and titles – scenario strategy	Wroclaw!
11.	City of strategic growth planning	Katowice!, Szczecin
12.	Intelligent and digital city	Kielce!, Krakow, Lublin, Lodz, Zielona Góra
13.	Strategic growth coherence on all levels	Gorzów Wielkopolski*, Zielona Góra*
14.	City of international cooperation and transport modes	Szczecin!
15.	Strategic diagnosis & realization	Lublin!
16.	Demography, economic activity and community	Poznan! Boat!
17.	City of support for people and families	Opole
18.	Cultural heritage of inner city	Gdańsk!
19.	*Chaotic topic*	Olsztyn!
20.	Media, energy and transport (dis)advantages	

! = the name of the city occurs with the largest marginal distribution in a given topic,
* the topic includes the abbreviation of the name of the regional development strategy of the Lubuskie Voivodeship.

Source: own study.

The topics that have been generated in the Topic tool seem to signal the dominance of the procedural bias to the development strategy. This is evidenced by the terms related to space and its planning (topics 1, 4, 9), strategic process (topics 3, 10, 15), development (topics 2, 11, 13), which are cross-cutting (not related to any particular city) or contextual for specific cities, whose names appear in sets of terms appropriate for a given topic. City residents are a common strategic theme (5, 6, 7, 16, 17) for specific cities. Among the groups of themes, it is also possible to distinguish more cross-cutting (two- and more-dimensional) ones relating to transport in combination with other elements of the city's infrastructure (20 – a cross-cutting theme, present in all strategies) or with international cooperation (14) due to the potential of Szczecin related to this theme. The topic related to Poznań and Łódź (16) is also multidimensional, considering terms referring to demography, economic activity and the community. It is worth noting that these are cities with a strong identity, just like Gdańsk (18), for which the dimension of the heritage of the old town has become the dominant terminology of the topic. Among the topics complementing the richest characteristics of Lublin, there is also the topic of cooperation between business and universities (8). On the other hand, the subject of smart and digital cities (12) has brought out among the part terms the names of cities that have referred to these concepts in their strategies. Due to the suboptimal number of segments in the city strategy corpus, there was also a chaotic topic, which included the name Olsztyn

among the terms. It is difficult to interpret a set of terms that, according to the calculation algorithm, should be assigned to one of the topics, and it is randomly included in topic nineteen.

Summing up the results obtained, it is worth pointing out that the analysis of the surveyed strategies signals that cities retain their autonomy in referring to global ideas, because regardless of the year of adoption, in some strategies the concept of smart city is absent or occurs incidentally (Szczecin, Wrocław, Bydgoszcz, Katowice, Gorzów Wielkopolski, Łódź, Zielona Góra, Warsaw, Gdańsk, Kielce), while in its place the term "smart city" is used as a polonized term. This resulted in assigning some of the cities mentioned to, for example, topic twelve.

Most often, smart activities were planned in strategies for the area of urban, energy and communication infrastructure, especially as the implementation of intelligent traffic management systems (8 strategies), smart grid or metering solutions (5 strategies) or infrastructure monitoring with the use of ICT (5 strategies) and for the area of city management (9 strategies) with the use of smart or intelligent solutions, or ICT, or smart city data management. Therefore, the partial scope of implementation of the smart city idea is noticeable, although in many cases the target strategic self-identification of the city is to achieve the status of a smart city.

5. Discussion

One of the most important dimensions of a smart city is technology and infrastructure. It affects a wide range of stakeholders and is a significant development condition for numerous – especially fast-growing – urban centers. Smart cities are based on the implementation of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI) and data management systems. These technologies allow for real-time monitoring and management of urban processes, improving transport efficiency, reducing resource consumption and improving public services. Cities, striving to improve the quality of life, implement modern technological platforms that improve communication between residents and administration (Calzada, 2017; Koman et al., 2024; Lange, Knieling, 2020). However, the implementation of such solutions is not without its challenges. In particular, public administrations are faced with rapid technological change, which entails the risk of inadequate adaptation of existing structures to new technological requirements (Astrain et al., 2022; Liang et al., 2021). The research also highlights the need to take into account the growing role of IoT and Big Data in the context of urban planning (Zhang et al., 2020; Zhao, Zhang, 2020; Zhou et al., 2016). Including this smart city area in the city strategy can lead to a number of technical, social and financial consequences. During the period of testing and improvement of the implemented technologies, problems often appear that may generate or worsen existing conflicts of interest between users of these solutions. Therefore, a precise and long-term strategic vision, resilient to political

changes in cities, consistently implemented and effectively communicated to individual stakeholder groups, is of key importance here. It should also be pointed out that there is a need for constant dialogue between the city authorities, residents, and entrepreneurs, who in the smart city concept are co-creators of the strategy, and therefore should be included in its development and modification. The area of modern technologies is particularly susceptible to the phenomenon of digital exclusion. Smart city is a concept in which it should not be an obstacle to the full use of the solutions available in the city. Therefore, this creates an added challenge of finding the needs of groups subject to such exclusion and preparing access to the city's offer for them. The strategies of the surveyed voivodeship cities primarily focus on solutions in the area of mobility – supplementing the missing transport infrastructure or improving it, as well as intelligent management of the network (smart grid), city resources or urban infrastructure. This means that it is necessary to invest significant funds in supplementing the transport infrastructure, which may limit the possibility of developing other dimensions of the smart city (e.g., Warsaw). On the other hand, as part of the already existing infrastructure solutions, cities are also taking actions aimed at perfecting the use of their resources through the use of IoT technologies.

Another important area of research is sustainability and the environment. Cities strive to effectively manage natural resources, including energy and water, while trying to minimize the negative impact on the environment. Reducing CO_2 emissions and improving energy efficiency are key elements of these measures (Christidis et al., 2024; Mutambik, 2024; Sabory et al., 2021). Examples of cities like Barcelona show that information technology can make a significant contribution to reducing emissions and protecting the environment (Astrain et al., 2022; Calzada, 2017; Ferrara, 2015; Mazlum, Ercoşkun, 2024). However, there are also challenges related to urban policy, which can lead to the depoliticization of environmental issues. Cities like Istanbul show that an integrated approach, combining urban and ecological goals, can support the ecological transition and sustainable development. On the other hand, voivodeship cities focus on sustainable development, often understood as increasing the value of natural resources (green spaces in the city) treated as a competitive asset of the city. The protection and development of the urban environment is still not necessarily associated with the harmonious development of urban fabric. Eventually, it is not possible to develop sustainably in a space where islands of greenery are inscribed in the network of concrete communication and residential routes, resulting in an uneven distribution of temperature in the city, with all its consequences.

Urban governance and social innovation (Ehwi et al., 2024; Noennig et al., 2024) This is another important thread of research in the context of smart city. Smart governance involves the use of modern technologies to improve communication between authorities and residents and to improve the quality of public services. The digitalization of city administration and the development of platforms enabling citizen participation are key elements of this process. Cities like Barcelona have a strong focus on inclusivity and citizen engagement in

decision-making processes, which contrasts with the more technocratic approach seen in cities like Singapore (Demirel, 2023; Noennig et al., 2024). Social innovation is a key tool for adapting the city's activities to the real needs of its residents. Also, the strategies of voivodeship cities consider the aspect of smart people in the spirit of activating residents and their creative potential for the development of the city. However, there stays an unresolved doubt as to whether the designed digital solutions will actually lead to the inclusion of all groups of residents in the development of the city. One can sometimes get the impression that enthusiasm for the possibilities of modern technologies leads to a more or less conscious resignation from cooperation with residents who do not use these solutions.

Research devoted directly to social inclusion and the concept of quality of life resonates with these issues. Inclusion assumes ensuring equal access to urban resources and services for all social groups, regardless of their social status, age or abilities. Greater equality in access to resources leads to an improvement in the quality of life – a solution in this area is being implemented, for example, in London. More livable (inclusive) cities are implementing assistive technologies, such as systems to support the elderly or people with disabilities (Neumann et al., 2023; Tekin, Dikmen, 2024) . Another dimension of social inclusion is the involvement of citizens in decision-making processes regarding city management, resulting in more responsive and inclusive urban policies (Tekin, Dikmen, 2024). Reaching such solutions requires setting strategic priorities in cities, considering the existing budget and time constraints. The example of Polish voivodeship cities shows that the area of smart people took the last place among the dimensions of the smart city concept included in the strategies. At the same time, it does not seem possible to generalize this observation to the approach of the city authorities to the residents, it rather seems to be a consequence of the discrepancy between the theoretical distinction of smart city dimensions in the classification of the University of Vienna and the more cross-sectional approach used in the practice of cities. From the perspective of municipal authorities, it is difficult to separate the issues related to the human factor included in the dimensions of smart people and smart living, because they overlap. Urban activists are the ones who exert the greatest influence on the decisions of the authorities, and at the same time they can lead to the overshadowing of groups less participating in the management of the city. That is why it is so important to diagnose the social reality of the city in strategies and to design actions on this basis that will enable the identification of the needs of all social groups present in the city. NLP tools can help here, as they allow you to process information expressed in natural language (Érces et al., 2023) in various forms of expression (from posted on social media, through interviews given orally or in writing, to correspondence conducted by the city with various stakeholders). It is important to be aware of the risk of omitting less or less active groups, which may sometimes stand for a significant percentage of the urban community. This can lead to limited access to relevant information and the design of strategic actions tailored to a small part of the city's population.

Modern technologies in smart cities also support urban security and smart building management (Hick et al., 2017). Advanced monitoring and management systems play a vital role in improving the safety of residents. An example is the projects in Budapest, where smart fire safety systems have been implemented to prevent fire hazards. Technologies such as *Building Information Modeling* (BIM) (In Palos, Shafi-Khah, 2021), which, by monitoring the technical condition of buildings, allow for precise management of infrastructure and forecasting of potential threats. This enables the integration of urban infrastructure management, increasing the safety of residents and the operational efficiency of cities. The use of intelligent safety systems in buildings supports sustainable urban development. They allow for monitoring energy consumption, control of the internal environment, as well as quick response to possible failures or threats, which significantly improves the quality of life of residents and contributes to saving urban resources (Clerici Maestosi, 2021). The strategies of voivodeship cities reveal the importance of this thread, which is in fact related to a wide range of activities focused on smart living, which came second (see Table 7). This is reflected in the recognition of potential savings achieved when cities check their own resources, e.g., housing. The benefits in this respect are also transferred to other residents who use the same buildings as owners of the premises located in them.

Finally, it is necessary to point out as an important area of research the challenges related to the management and implementation of the smart city strategy (Mutambik, 2024; Noennig et al., 2024). The implementation of smart city technology requires managing the diversity of stakeholders and balancing technological goals with social needs. Effective implementation of strategies often requires close cooperation between different sectors and levels of administration. Examples from different cities show that the integration of urban policy with technology can face obstacles related to efficiency and social justice. A key challenge for cities is to strike a balance between the pursuit of innovation and ensuring social equality and meeting the needs of their citizens. In this context, the research of Lange and Knieling (Lange, Knieling, 2020) and Yun to Lee (Yun, Lee, 2019) They present how cross-sectoral cooperation can support the implementation of smart city strategies at the local and global level. Against this background, the strategies of voivodeship cities, which focus on the area of smart governance primarily on data management to make more proper decisions, are interesting.

The picture of the implementation of the smart city concept in city strategies in the light of world literature, as well as Polish voivodeship capitals, seems to be quite similar – despite some details. The solutions described in the literature are often partial and this is also the case in the strategies studied. The postulate of a holistic approach to the issue of introducing the idea of smart city in cities formulated in the literature is justified by the described examples or reviews of actual implementations. The main challenge in this context seems to be the discrepancy between the idea of a smart city as the goal of the strategy and the problems that arise during its implementation. Considering the most important criteria for urban communities, i.e., the scope of smart city implementation and the degree of adaptation of this implementation

to the needs and potential of the city, it is possible to roughly organize the possible implementation options into the following options:

1. striving to implement the smart city concept with the transfer of solutions proven in the world, although not fully adapted to the potential of a given city,
2. implementation of selected smart solutions dictated by the current needs of the general public or selected stakeholder groups, which leads to the extension of the period of achieving the smart city status while being more closely aligned with the city's potential,
3. implementation of typical smart city solutions to achieve the status of a smart city, usually treated as a panacea for the ills of a given city.

In order to fully use the possibilities inherent in the concept of smart cities, it seems that it is necessary to conduct deeper research on the paths of achieving its potential by cities, as well as on the typification of these paths. It also requires an analysis of the effectiveness of the results achieved by cities with the smart city status in terms of matching the needs of various stakeholder groups. Only as a result of comparing data on the city's strategic intentions, in the context of the smart city concept, its actual achievements and their assessment by the interested parties with the way they are achieved by the city authorities, can strategic recommendations be developed describing the best possible development trajectories for those cities that see sense in striving for development in accordance with the idea of a smart city.

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