Factors and barriers to the development of smart urban mobility - the perspective of Polish medium-sized cities

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Abstract

The main purpose of this paper is to indicate factors and barriers to the development of smart mobility in Polish medium-sized cities. A combination of three methods was used (mind mapping, STEEP analysis, and panel discussion). They were carried out during expert workshops with the participation of representatives and presidents of 14 cities, during the 4th Industrial Forum in Karpacz, December 2019. The paper first presents the general concept of the smart city and smart mobility development. Then, the most important factors and barriers to the development of smart mobility in Poland were formulated on the basis of the research. The article has important value from the point of view of urban study researchers and city governance practitioners. The results from the study would be of interest to those in similar settings, as it contributes with valuable insights on how the chances of implementing smart mobility assumptions are perceived in the opinion of medium-sized cities' representatives. The paper contributes to the knowledge of city governance and new business model managers (data-based services). It helps to recognize and consider uncertainties they are likely to face.

Keywords: *smart mobility; smart cities; open-data, data-based governance, IoT, big data*

1. Introduction

Cities are characterized more and more by "mega-trends" which are going to crash their balances (Kanter & Stanley, 2009). While cities play an important role in social and economic development, they also have a huge impact on

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the environment (Mori & Christodoulou, 2012). In 2019, 55% of the global population lived in urban areas; however, by 2050, over 66% of global population will live in cities. Demographic change and climate crisis require a quick and radical reaction. This pressure is even more pronounced in Europe, with more than two-thirds of the population already living in cities. Even in Poland, with only four cities with half a million citizens and one city with over 1 million citizens, city dwellers make up over 60% of the total population. In the context of mobility, one piece of information seems important: the lower the urban density, the more energy is consumed for electricity and transportation, as proved by the fact that CO2 emissions per capita drop with the increase of urban areas density.

Both research and examples concerning the implementation of the smart city idea concern mainly large cities and metropolitan areas. Medium-sized cities, which are numerous in Poland, remain outside the spectrum of interest in scientific research. Although the cities have to deal with the effects of advancing globalization trends, their residents feel the overwhelming need for consumption that has been inaccessible to them for a long time. Awareness of the climate crisis, difficult access to unpolluted air, deteriorating quality of life and threat to health do not penetrate as deeply into the consciousness of residents as to mobilize them to self-limitations in the sphere of consumption. Taking into account just the automotive aspect, according to the Busradar Report (2018), in Poland, there is still a belief that one of the measures of the level of household welfare is having a car (46% of respondents think so). 86.6% of households have at least one car, 25% have two cars. In Poland, there are 571 passenger cars per one thousand inhabitants. This is less than in Italy (625 cars per thousand inhabitants), but more than in Germany (555), Spain (492), or France (479). The heavy traffic does also include public and freight transport, causing congestion, air pollution, and noise. The congestion of cities also means problems with the availability of parking spaces, the growing number of road accidents, increasing medical costs, and other economic effects (Welle et al., 2018). Other problems of medium-sized Polish cities include urban sprawl, urban depopulation, increasing road congestion and environmental pollution, economic instability in the global economy, and the phenomenon of an aging society.

Along with the dynamic expansion of urban areas, effective urban development becomes a priority for both large metropolises and cities remaining outside the world leaders. Sustainable and modern ecological cities are perceived as a key condition to avert the climate crisis, improve the quality of life, and (in the case of smaller urban units) stop the outflow of residents. The strategic role of cities in the social, economic and environmental development of modern economies implies the need for scientific discussion on the vision and directions of their development. This is not only in relation to the implementation of the new generation of information and communication technologies (ICT) supporting the service of residents but also in the context of generating and implementing ecological innovations (reduction of carbon dioxide emissions, energy efficiency) and modern social solutions. In particular, contemporary mobility planning, due to the need for strong stakeholder involvement, extensive public consultation and preparation of a comprehensive plan, is an extremely complex and time-consuming process.

Ten years ago, the European Commission (EC, 2009) pointed out the need for integrated transport planning in accordance with the principles of sustainable development. The December 2013 Communication (EC, 2013) presented a detailed package of actions on mobility, largely devoted to urban mobility planning. Thus, attention was drawn to the importance of a strategic approach, as well as the integration of transport planning (including accessibility and mobility) with the areas of spatial planning, environmental protection, or health. The instrument that allows the implementation of such a policy in accordance with the recommendations of the European Commission is the Sustainable Urban Mobility Plan (SUMP), the development of which in individual cities is optional for now. The largest Polish cities are already undertaking activities to develop their own documents (e.g., Wroclaw, Warsaw, Gdynia, Gdansk, and Krakow). For now, none of the smaller cities has shown interest in this venture.

Unlike traditional transport planning, this process should focus not only on providing better traffic conditions but primarily on striving to ensure the highest quality of life for residents, prioritizing aspects such as accessibility, social equality, health, and environmental protection. Therefore, the ability to identify and meet the needs of various city development stakeholders seems to be a significant challenge.

2. Literature background

2.1. A comprehensive framework for a smart city and a city's stakeholders concept

The smart city concept has received increasing attention during the last two decades along with the rapid technological advancement. In the area of the EU alone, over 1300 smart city related proposals, commitments, and projects exist. Cities worldwide have started to look for solutions that enable transportation linkages, mixed land uses, and high-quality urban services with long-term positive effects on the economy. For instance, a high-quality and more efficient public transport that responds to economic needs and connects labor with employment is considered a key element for city growth. Many of the new approaches related to urban services have been based on harnessing technologies, helping to create "smart cities" (Albino et al., 2015).

The goal of the smart city concept is a modern urban data-based management, considering the applicable ecological standards while saving resources and achieving the expected results. Predominantly this term is understood as a certain intellectual ability that addresses several innovative socio-technical and socio-economic aspects of growth (Zygiaris, 2013). Researchers, multinational companies as well as governments are strongly pushing towards smarter approaches for cities, but it is still missing a common understanding and an embedded well-acknowledged definition of such an initiative (Caragliu et al., 2011). Despite the confusion about what a smart city is (Anthopoulos, 2015; Vanolo, 2014; Yanrong et al., 2014; Gil-Garcia et al., 2015; Granath, 2016; Hollands, 2008; O'Grady & O'Hare, 2012), several similar terms are often used interchangeably. The discussion revolves around issues such as "digital city" (Besselaar et al., 2005; Tan, 1999; Yovanof & Hazapis, 2009), "intelligent city" (Komninos, 2008; Harrison et al., 2010), "knowledge city" (Dirks, 2009; Carrillo, 2004), "information city" (Sproull & Patterson, 2004; Stolfi & Sussman, 2001), "ubiquitous city" (Lee et al., 2008; Shin, 2009), "smart communities" (Kanter et al., 2009), and much more.

BSI PAS 180 (2014) provides the following working definition: smart city is a term denoting the effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens. The ITU-T Focus Group on Smart Sustainable Cities analyzed nearly 100 definitions and used these to develop the following one: "a smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects".

Some definitions of an intelligent city emphasize primarily technological issues, while others do concentrate on social ones. Harrison et al. (2010), in an IBM corporate document, stated that the term "smart city" denotes an "instrumented, interconnected, and intelligent city." "Instrumented" refers to the capability of capturing and integrating live real world data through the use of sensors, meters, appliances, personal devices, and other similar sensors. "Interconnected" means the integration of these data into a computing platform that allows the communication of such information among the various city services. "Intelligent" refers to the inclusion of complex analytics, modeling, optimization, and visualization services to make better operational decisions

(Harrison et al., 2010). Nam and Pardo (2014) claim that a city can hardly become smart because of technology alone, while for corporations (Cisco Systems, Siemens AG) the technological component is the key component to their conceptions of smart cities. Peng, Nunes, and Zheng (2017) defined a "smart city" as a city using a set of advanced technologies, such as wireless sensors, smart meters, intelligent vehicles, smartphones, mobile networks or data storage technologies". Similarly, Guo et al. (2017) stressed the urban development based on the integration of many information and communication technology (ICT) solutions to manage the city's resources.

The abovementioned approach has been critiqued by Greenfield (2013) who argues that corporate-designed cities such as Songdo (Korea), Masdar City (UAE), or PlanIT Valley (Portugal) lose sight of the individual functions of the city, disregard the value of complexity, unplanned scenarios, and the mixed uses of urban spaces. Caragliu et al. (2011) state that a city is really smart "… when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (p. 70). The majority of researchers (Cugurullo, 2013; Kitchin, 2014; Vanolo, 2014) emphasize that technology could be used in cities to empower citizens by adapting those technologies to their needs rather than adapting their lives to technological exigencies.

According to Albino et al. (2015), one of the reasons for the lack of a universal definition of a smart city is the fact that the abovementioned concepts fall into two different dimensions. The first of them refers to the so-called hard components (i.e., intelligent infrastructure, mobility and logistics, energy networks, water and sewage management, waste management) where ICT technologies are of key importance. The second context emphasizes soft components (relations, education, culture, social inclusion), where the use of ICT is not usually a priority.

A review of the literature indicates that the concept of a smart city quite often combines the digital dimension with the social dimension. As a common perception, the concept of a smart city coincides with a digital city and refers to the development of a broadly understood ICT infrastructure, which is flexible and service-oriented as its purpose is to meet the needs of all stakeholders: local authorities, entrepreneurs and residents (Yovanof & Hazapis, 2009). In this approach, the city's intelligence means its ability to support the development of all its inhabitants. Therefore, it should be pointed out that not every digital city is intelligent, while every intelligent city contains a digital component (Albino et al., 2015). In a similar spirit, Hollands (2008) notes that the concept of a smart city refers to building an ICT-based infrastructure to support social and urban development, by implementing economic solutions, engaging residents, and improving management efficiency. Manville et al. (2014) define a smart city as a city where public issues are solved using ICT, with the involvement of various types of stakeholders working in partnership with the city authorities. Yet, more collaborative research is needed in order to help practitioners understand when technology is the solution, and when it is not (Glasmeier & Christopherson, 2015).

Numerous studies have been undertaken on smart city assessment frameworks (e.g., Carli et al., 2013; Neirotti et al., 2014). They invariably work their frameworks from the findings of the Technical University of Vienna research group, who indicated six original dimensions including economy, people, governance, mobility, environment, and living (the last issue raises some doubts, because living conditions are the result of previous elements and therefore it is difficult to treat them as a separate category). Albino et al. (2015) pointed out the following features of smart cities: (a) network infrastructure that enhances the effectiveness of political and social activities as well as cultural development; (b) business and creative activities undertaken to promote urban development; (c) social inclusion of urban residents and the involvement of social capital in urban development, and (d) the natural environment as a strategic component of the future.

Ortiz-Fournier et al. (2010) described a smart city in the context of its intelligent inhabitants, the quality of social interactions, and integration with public life. In the current perception of the smart city concept, the attention is focused on the needs and preferences of the inhabitants – technical solutions should just serve their interests. Having that in mind, the city's special "intellectual ability" should cover the social and technological aspects of green economic growth, which is used to formulate the definition of a smart city as a green city in relation to its ability to solve environmental problems (Zygiaris, 2013; Beretta, 2018).

As the concept of an intelligent city takes into account the human component, it emphasizes the key role of education, science, culture and knowledge in the development of modern urban initiatives. For this reason, "knowledge city" invests in knowledge-based solutions, and contributes to creating value in both the private and public sectors (Carrillo, 2004). The development of this concept was inspired by the emergence of cloud computing technology and their application in urban service provision systems. Open access to data contributes to the creation of new urban architecture that encourages the collection, processing and sharing of knowledge through widely available mobile devices. Trying to combine the abovementioned aspects, Komninos (2011) points out four key dimensions relating to (a) the use of ICT to build a digital city; (b) the use of ICT to improve living and working conditions; (c) the use of ICT in an advanced urban infrastructure;

and (d) the integration of ICT with human capital to stimulate innovation and the accumulation and sharing of knowledge.

Obviously, the future Internet domain landscape comprises a great diversity of technology related topics involved in the implementation of smart cities, e.g. ubiquitous computing, networking, open data, big data, geographic information system (GIS), cloud computing, service-oriented architecture (SOA), e-government, embedded networks and internet of things (IoT). These technologies overcome the fragmented market and island solutions of smart cities applications and provide generic solutions to all cities, but still the main target for developing smart cities is to pursue convenience of public services; delicacy of city management; livability of the living environment; smartness of infrastructures and long-term effectiveness of network security. Therefore, the term smart city also refers to ways of managing public space and effectively solving social and environmental problems in the city (Van der Meer & Van Winden, 2003). This is in addition to using information and communication technologies to increase the interactivity and efficiency of the urban infrastructure and its components, as well as to raise the awareness of its inhabitants (Azkuna, 2012).

A city is a complex system composed of a fusion of individuals with carried competencies, personal values. Smith and Ingram (2002) address the importance of stakeholders' participation in the context of new governance, and Bifulco et al. (2014) claim that the coming of a smart city requires a transformation in the interpretation of stakeholders' roles and participation. Transformation from a non-smart city to a smart city entails the interaction of political and institutional components with technology as the smart city innovation (Mauher & Smokvina, 2008). According to Purao et al. (2013), one of the constituents distinguishing smart city management is citizen participation.

A stakeholder is any group or individual who can affect or be affected by the achievement of an organization´s purpose (Freeman et al., 1984). Every city is also a system of stakeholders (Belissent, 2010) and incorporating them into the smart city management means balancing interests and muffling all obstacles (Roy, 2005). Co-creation in service design is usually referred to as value co-creation (Vargo & Lusch 2008) which is an integral subject of service-dominant logic paradigm. Value proposition is associated with the stakeholder relations and business model design. Value is linked to benefits (Rescher, 1969) each stakeholder is seeking from the value networks and stakeholder relations. The value may occur in the form of financial profits, cost savings, goods, services, knowledge or in improved quality (Sainio et al., 2011; Allee, 2008), but received value may further emerge in-directly in the value networks (Allee, 2008; Ojala & Tyrväinen, 2011). Government, academic institutions, and the private sector can only offer value propositions to the citizens and actual value is created collaboratively, making citizens co-creators of value (Lusch & Vargo, 2006), while acknowledging that citizens – as consumers – participate in the development of the core offering itself and view it as a component of value cocreation. Maglio and Spohrer (2008) argue that a service system is defined as a configuration of people, technologies, organizations, and shared information that are able to create and deliver value to the interested entities through service. According to Polese (2009), interaction becomes the driver of value, which develops a joint process of value creation in the service system, and city performance is not only supported by and measured by the hard infrastructure, but also the availability of social and communication improvements. The smart city strategy acknowledges the common goals and value creation possibilities to citizens and stakeholders in public and private sectors by means of digital technologies. Therefore, an explicit smart city design clarifies complex smart city governance, stakeholder relationships, orchestration, and decision-making procedures (Scuotto et al., 2016; Vilajosana et al., 2013), and advances technological compatibility and correct resource allocation in cities (Carvalho, 2015; Scuotto et al., 2016; Vilajosana et al., 2013), but above all smart city initiatives should aim to improve the quality of citizens lives.

3. Main concepts of smart mobility and sustainable mobility

Intelligent/smart mobility is usually indicated as the most desirable option for sustainable transport systems (Pinna et al., 2017). The "smart mobility" concept and methodical origin can be found in the smart city paradigm (Albino et al., 2015; Neirotti, 2014). Benevolo et al. (2016) define smart mobility as "a set of coordinated actions to improve the efficiency, effectiveness and environmental sustainability of cities" (p. 70). The main aspect of intelligent mobility understood in this way is connectivity, which, based on big data, allows users to share, acquire and analyze all traffic information in real time, which is also a determinant of dynamic management at the local government level (Pinna et al., 2017). In this approach, intelligent mobility must cover the entire passenger-transport management system, tracking applications and logistics, parking management and car sharing services (Yue, Chye, & Hoy, 2017). More attention is also required for pedestrians, including people with reduced mobility (development of accessibility standards, provision of information, promotion of pedestrian traffic and the gradual creation of safe and attractive mobility conditions).

As a component of a smart city, transport or mobility relates to the "hard," 'techno-centric' domain of smart city, both in theory and to a great extent in practice. This is reflected in much of the investment and innovation in the 'mobility' sector (Neirotti et al., 2014). The transport and mobility domain has the highest number of initiatives worldwide within the approach to smart city (Papa & Lauwers, 2015). A large share of the studies in the field of smart mobility is related to sustainable thinking (see for example, Mangiaracina et al., 2012; Lyons et al., 2012; Agha, 2016). According to Benevolo et al. (2016), research into the rapidly evolving initiatives within smart mobility falls largely under two sub-fields. The first is alternative fuels and propulsion vehicles (including electric, hybrid, hydrogen, fuel cells, and Compressed Natural Gas (CNG) vehicles). The second is the integration and assimilation of ICT into the traditional road transport and automobile sector, enabling it to produce new travel forms and practices. These are automated and autonomous features and vehicles, integrated and connected vehicles, users' apps for car sharing, car-pooling, ridesharing, ticketing, parking, navigation, and information. Finally, there is also Intelligent Transport System (ITS) including transport infrastructure technologies for collecting data, analyzing it and creating dynamic smart traffic control systems that monitor and manage the demand for and supply of transport (Benevolo et al., 2016, pp. 17–24).

Pursuant to EU Directive 2010/40/EU, intelligent transport systems "integrate telecommunications, electronic, and IT technologies with transport engineering for the planning, design, operation, maintenance and management of transport systems" (p. 14). Modern technological and organizational solutions, on which intelligent transport systems (ITS) are based, enable, among others, traffic control and the creation of special zones with limited access and low CO2 emissions by limiting the number of private cars in designated areas of cities. Their goal is also to increase the safety of traffic participants and to improve the efficiency of the transport system, and indirectly to protect the environment. ITS also enables better information, sending alerts ("push" system), safer, better coordinated use of transport networks, the ability to manage the handling of large events, traffic control and quick emergency response (crisis management). Most scientific research confirms that ITS supports smart urban mobility (Mangiaracina, 2017; Papa et al., 2017; Battarra, Zucaro & Tremiterra, 2017) by reducing traffic congestion, reducing air pollution, increasing energy efficiency, and promoting the development of related industries (Chandra, Harun, & Reshma, 2017).

New mobility services and business models are changing urban transport, affecting both the supply and demand sides of the urban mobility market. App-based mobility services such as car and ride sharing and Mobility as a Service (MaaS) through single or integrated ticketing services, offer new possibilities to expand and complement existing mobility and can help to balance public and private transport in cities. Evidence shows that these developments can lead to a significant reduction in single occupancy private car use and an increase of public transport use, leading to a strong reduction in congestion, local air pollution, and CO2 emissions (ITF, 2015; 2017). These benefits will occur when more vehicles are shared and private car ownership is reduced. Under these conditions, new mobility can change the way people live in cities. This illustrates the magnitude of the change and the important benefits resulting in moving towards an increasing use of shared mobility, public transport and integrated use of various mobility services.

The shift from conventional mobility to sustainable mobility involves moving from an idea of transport system performance, primarily evaluated based on speed, convenience, and affordability of motor vehicle travel to a more comprehensive, multimodal system of evaluation that considers a range of modes, objectives, impacts and improvement options (Litman, 2013). The sustainable mobility paradigm (Banister, 2008) strengthens links between land use and transport (sustainable in the senses of social, environmental, and climate aspects). It is clear that the capacity of the transport system could not continue expanding. Sustainable mobility is aimed at the ultimate goal of mobility, which is accessibility (Kennedy et al., 2005; Litman, 2013) and can be referred to as access-based.

An interesting approach to overcome the conventional mobility planning can be defined as the "place making" paradigm (Jones & Evans, 2012; Cervero, 2009; Gehl, 2013). The key drivers configuring the urban fabric and creating a place are referred to as the 5D paradigm (density, diversity, design, distance to transit, and destination accessibility). The attention has been directed to the people and the places of the city and the emphasis is on the creation of quality of urban places while in "conventional" mobility planning the smart mobility approach gains the most importance (the potential of optimizing existing city infrastructure, services, and urban behavior through the deployment and utilization of new technologies). A "place making" paradigm seems to be closer to the consumer-centered smart mobility approach, which is characterized by a strong emphasis on the human side. It combines a strong focus on putting the customer at the heart of the service offering with the requirement of integrating all transport opportunities into a whole system: the user and their experience and requirements must be at the center of mobility provision (Papa & Lauwers, 2015).

New mobility services range from shared mobility such as car, bike and ride-sharing services to multimodal, door-to-door trip planning, and mobility as a service. They complement city public transport services by providing mobility solutions for the first and last mile, reaching less dense or underserved areas and developing integrated ticketing or payment services, providing attractive and comprehensive mobility options also for those whose needs haven not been fulfilled by traditional public transit services and thus channeling some new demand and custom for public transportation system.

4. Research approach and methods

As the aim of this study is to understand the complexity in a city's mobility planning processes and how this complexity affects the outcomes when realizing smart city ambitions, a combination of three qualitative and interpretative methods was used: a mind mapping technique, a STEEP analysis (see below) and a panel discussion. The discussion was carried out during expert workshops with the participation of representatives of seven medium-sized cities, attending the 4th Industrial Forum in Karpacz, in December 2019. Namely the representatives of Legnica, Jelenia Góra, Konin, Tarnowskie Góry, Grudziądz, Jaworzno and Sobotka (all the cities are situated in Poland and each of them has from 80,000 to 100,000 inhabitants). Altogether 57 people took part in the workshop discussion.

The purpose of the STEEP analysis was to identify the external environment factors that are opportunities and threats for intelligent mobility projects in medium-sized cities, and to determine the strength of this impact. The criteria covered by the STEEP analysis typically include (1) socio-cultural factors (values, lifestyle, demographic growth, religion, level, education, employee qualifications, population income, society's attitude towards a given industry), (2) technological factors (scientific discoveries, patents, technology level in a given industry, impact of new technologies, changes in the organization of production), (3) natural environment (environmental protection, pollution, climate change, renewable energy, recycling), (4) economic factors (GDP, inflation rate, unemployment rate, budget deficit, market size, interest rates, taxation, exchange rate currency, trade and payment balance, level of wages) and (5) political factors (regulations regarding economic activity, attitude of the authorities towards industry, socio-economic ideology of the government, stability of governments, stability of legal regulations, (re) privatization processes, EU membership).

All the participants of the STEEP analysis process took part in two working panels: the first one was aimed at the identification of factors constituting opportunities or threats to smart mobility in medium-sized cities, while the second one was devoted to the quantitative assessment of the importance of STEEP factors. The scale adopted for the purposes of the analysis (1-5) indicated:

5 - a very encouraging environment
4 - encouraging environment
3 - neutral environment

2 - non encouraging environment
1 - strongly discouraging environment

Interviewees were also asked to mention the three most negative impacts (outcomes) or unsustainable features of today's transportation system in their cities and then, rank them by order of importance from the most influential (1) to the least influential (5). In the last stage of the discussion they were asked to suggest (or report) the possible solutions to addressing the most pressing issues of urban mobility. The interviewees were asked to consider a social perspective to their responses instead of their personal preferences.

5. Research results

Discussion on the opportunities and threats of implementing smart mobility has shown quite different opinions on the importance of different factors. First, the workshop participants have indicated smart city decision factors, enumerating two groups. The first one includes citizen participation, leadership and infrastructure, as internal factors. The other one (external factors) covers: the idea of data-based management and a decentralized approach to innovation.

The main stakeholders of an intelligent mobility include: residents and guests (tourists), local government, budgetary units, municipal companies, educational units, universities and research centers, business entities. They all should be offered a promotional campaign to build a "front" of interest and support. During the workshop, all the stakeholders surrounding the smart city were divided into direct and indirect ones. The first group includes: residents and city government, government, and local enterprises. Urban authorities are the main actors in building smart cities and delivering services to citizens. In contrast, urban residents and enterprises should become the most direct beneficiaries of smart city services (citizens benefit from the improved quality of life, while local enterprises can benefit from creating new profits by leveraging smart city infrastructure). An indirect stakeholders group includes providers of smart technology, infrastructure services, and applications.

The most important postulates of the debate participants concerned the following issues:

1) resident participation in urban policy decisions – in this respect, there was an urgent need to develop tools that would enable residents express their wishes and seek solutions to them. These tools should take into account the significant impact that ICT has had on the behavior and communication of various entities, and thus, the specific expectations of residents regarding the availability of public services, the possibility of submitting comments and demands. It has been argued that the expansion of citizen participation in the form

of bottom-up, experimental innovation; open-source platforms; and living labs appeared as a new urban plan.

2) the leadership of the local governor – the success or failure of a smart city policy largely depends on the pace of implementation and diffusion of technological solutions. The debate participants emphasized, however, that the idea of a smart city cannot be reduced to the computerization of the municipality, which is too often the case in Polish cities. A suggested solution to this problem may be the inclusion of an IT director in the team responsible for building an intelligent city in the area of infrastructure, digital solutions, long-term financing, appropriate allocation of expertise, employee education, staff accountability, and the standardization and interoperability of systems.
3) data-based management – the basis of the smart city concept is the development search for new data sources and investment in the development of intelligent infrastructure that allows data generation, acquisition, exchange and analysis in real time (artificial intelligence, wireless communication, the IoT, GPS positioning, etc.).
4) a decentralized approach to innovation – specialized knowledge cannot be sought solely within the government – it comes from various sectors of society.

The concept of smart cities in a simplified way consists in investments that are focused on sustainable economic growth of the city and improving the quality of life of the inhabitants. The most important thing is that they are to take place not only by the expansion of the broadly understood infrastructure (transport, ICT), but also one of the more important goals is to involve the citizens living in the city to participate more fully in the life of the agglomeration. At the same time, the participants of the debate emphasized the fact that transport is a special kind of activity, strongly based on intelligent solutions. The benefits of their use are felt by all city users – residents and entrepreneurs, authorities, tourists, etc. Firstly, good transport solutions determine the level of social, economic and even political inclusion of residents. Well-organized transport affects the flow of traffic, increases the comfort of movement, staying in the city (e.g. when limited traffic zones are created) and, finally, the comfort of life (reduction of air and exhaust emissions, thanks to the implementation of low- or zero-emission solutions, decreasing noise, shortening travel time, improving road safety and reducing the degradation of road infrastructure).

The implementation of modern ICT solutions supporting the development of sustainable transport in order to optimize communication processes and population mobility is an extremely important direction of activities. In large Polish cities, multimodal passenger applications serve this purpose, which allow real-time traffic monitoring. They allow you to determine how much time it actually takes to travel to a given place by a specific means of transport and, if necessary, decide whether to opt-out of using the car. The most advanced solutions allow a counteraction to the dominance of individual communication and promote alternative forms of mobility based on multimodal passenger transport systems (coordination of the entire displacement chain implemented by various means of transport with a combination of individual and public transport, e.g. in Park & Ride or Bike & Ride mode). None of the cities in question has this type of solution, although some have the dramatic consequences of excessive car traffic and cannot cope with the lack of parking spaces.

The results of discussions on opportunities and threats in the implementation of smart mobility principles, the participants identified a comparable number of favorable and unfavorable factors, but clearly assigned a higher weight to threats (Table 1.3).

According to the interviewees, sustainable, data-based transport is one of the main elements constituting the smart city. Even the medium-sized agglomerations face many problems that did not seem so large a few decades ago. Neglect in the quality and availability of public transport services in the small urban centers examined have strongly influenced the mobility behavior of residents. However, this can be seen as an opportunity: the creation of smart mobility frameworks should acquire at the same time an appropriate technical and digital infrastructure, as well as simultaneous actions to change the communication behavior of residents.

On the opportunities side, the interviewees pointed to environmental issues and socio-cultural changes. Lower hopes are associated with economic issues (they perceive them mainly in terms of increased costs at the first stage of implementation), political and – the least – technological factors (see Figures 1.1 and 1.2).

The most desirable solution, suggested by the participants of the debate, would be cooperation with telecommunications operators in the scope of analyzing the whereabouts of users of a given network and their mobility route. Nowadays, femtocells allow you to locate the user with an accuracy of 100 meters, so you can visualize and interpret traffic within the city. These data should be combined with data from other sources (motion detectors, electronic toll systems, traffic lights, tunnel management systems, cameras and speed cameras, and even weather systems). In public transport, ICT solutions should make digital tickets available online.

Table 1.3. Opportunities and threats to the implementation of smart mobility assumptions

Factor	Opportunities	Threats
Socio-cultural	• the improvement of mobility solutions • improved safety and quality of life • social interest in solutions known from large urban centers • lifestyle • education level and health awareness • demographic trends • promoting a healthy lifestyle	• fear of a change in the scope of transport solutions used (resignation from private transport) • shortage of qualified staff (programmers, architects, planners) • lack of public confidence in modern transport solutions
Techno-logical	• new technologies • ICT development • market niche • patents, inventions and intellectual property protection • level of digital literacy in society • growing acceptance and interest in modern solutions in the field of urban bicycle systems and scooters	• high technology competition on the international market (pressure on the costs of applied solutions, low profitability and low scalability of solutions and applications offered by local entrepreneurs) • technical base/condition of technical universities
Environ-mental	• reducing the number of vehicles • lower energy consumption • reduction of water and air pollution • technology that does not use harmful substances	• potential increase in environmental risk by introducing unknown solutions • the increase in energy consumption associated with new needs • production of harmful waste during the operation of equipment
Economic	• development of (small and medium) high technology enterprises • reduction of costs related to utilization of pollution, crowds, noise, lack of parking spaces, losses in urban greenery, number of accidents and costs of treatment of victims • availability of funds for the development of environmentally friendly technologies • growing indicator of implementation and commercialization of innovative technologies • market size	• costs of changes in the area of city architecture, communication solutions, new investments, purchase of new vehicles, development of the city bike system • the cost of experts (smart mobility issues) and programmers • low implementation rate and commercialization of innovative technologies
Political	• increase in technology development financing • developing a coherent strategy for the development of smart mobility on a national scale (indicating priority development directions) and European guidelines • national scientific and research base	• funding for research in the field of smart mobility • no incentives for launching commercial enterprises with a large „know-how" contribution • lack of units supporting researchers in obtaining/financing patents • no legal regulations allowing for quick technology implementation

Source: Own elaboration based on the results of STEEP analysis.

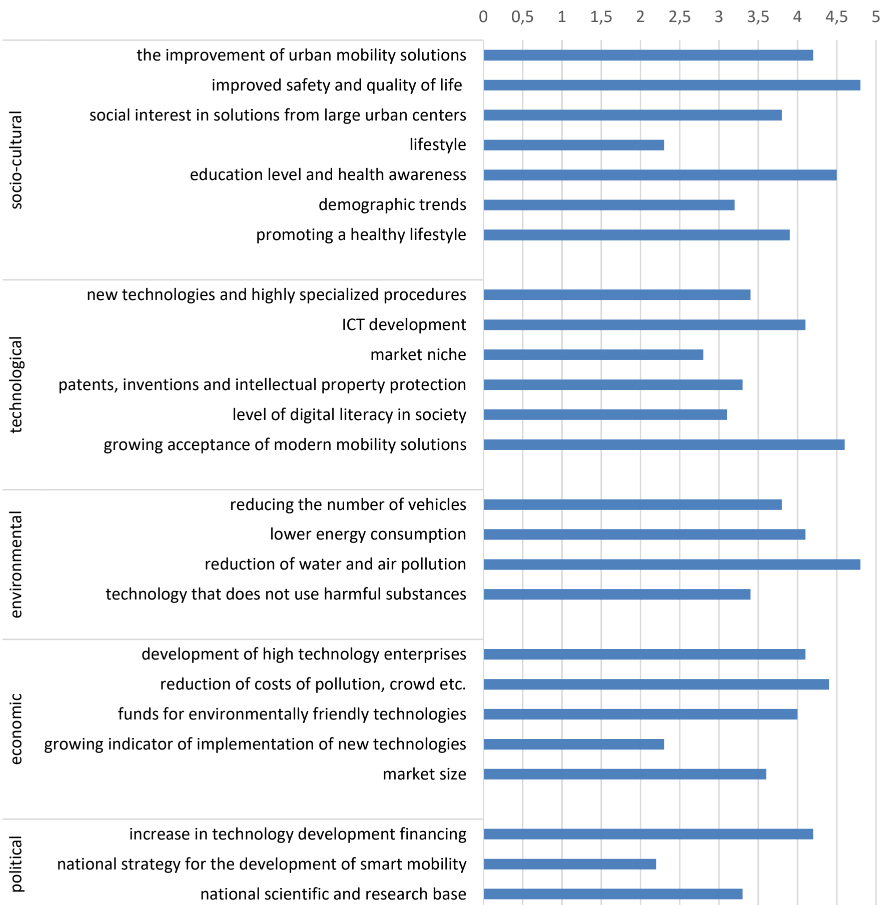

Figure 1.1. Opportunities for the implementation of smart mobility assumptions

Wireless Internet in public transport is an additional source of data for the passenger information system, which should inform a mobile application about, for example, the location of the nearest vehicle, the best available configuration of transport connections or available parking spaces (with the possibility of paying a fee). The application should also allow you to indicate the place where the car was parked, and to watch the car.

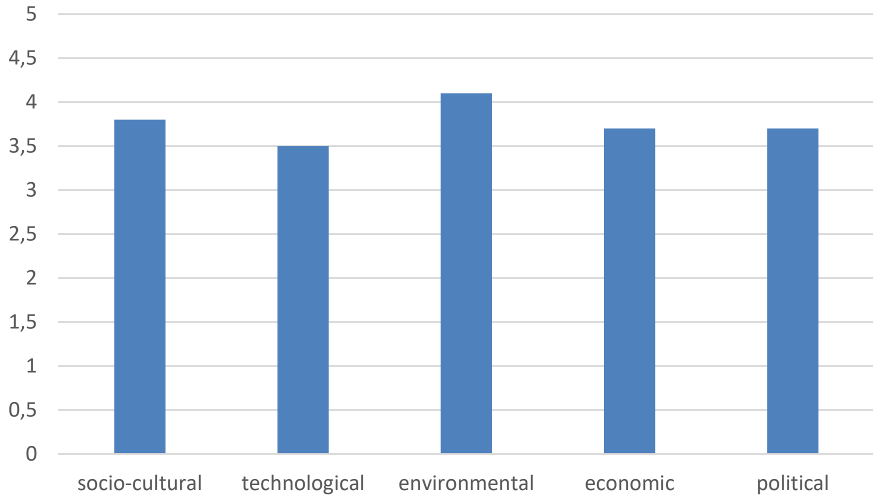

Figure 1.2. Key categories of opportunities for the implementation of smart mobility

Much higher weights were given to threatening factors, including in particular: technological and socio-cultural factors, which – in general – covered resistance to change, insufficient technological competence (including low universities support) and the lack of qualified staff (Figures 1.3 and 1.4). The main obstacle to implementing future-proof solutions is the lack of sufficient funds and the inability to communicate and cooperate with various institutions. Therefore, the implemented projects usually do not have a holistic approach, and in the field of transport, they most often amount to traffic regulation.

The majority of interviewees drew attention to the negative aspects of urban transport, having regard to both the effects in terms of its efficiency and environmental footprint. The concept of low efficiency covers both: the issues related to the costs of operating a car fleet and the costs of the user (time spent traveling, searching for parking, fuel costs, and vehicle depreciation).

According to interviewees, the negative impacts of the transport system covered: environmental impact (98%), congestion (time, cost) (100%), inefficiency (fuel, energy, vehicle) (76%), bad service public transport (82%), bureaucracy (11%), high cost of transport (39%), low safety (64%), automobile dominance (7%), lack of infrastructure (23%), uncertain future (12%), lack of intermodality (22%), “not smart” (67%), insufficient parking (94%), human factor/behavior (43%), level of motorization (23%), no sharing of resources (8%).

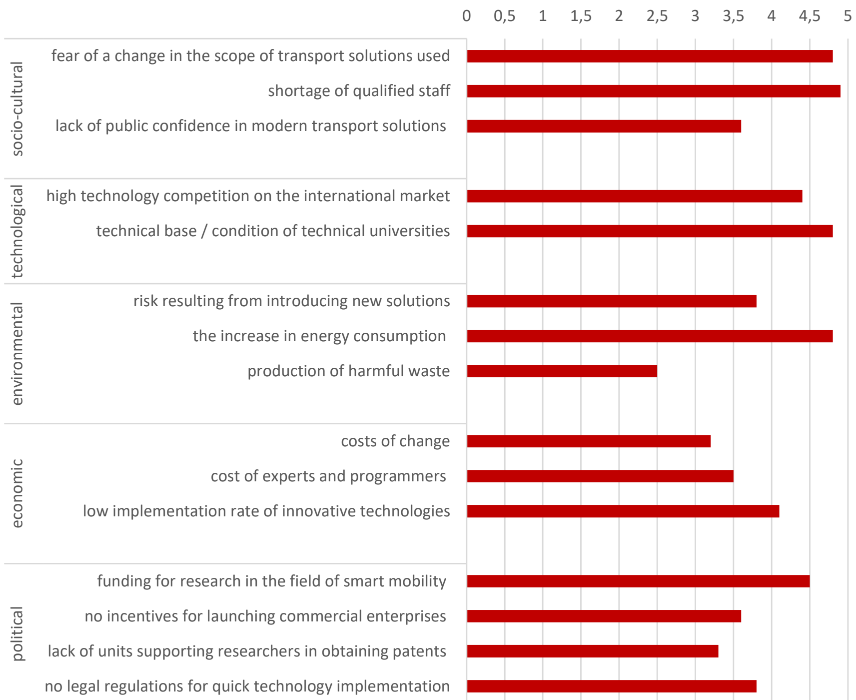

Figure 1.3. Threats to the implementation of smart mobility assumptions

Only a relatively small share of the interviewees suggested or hinted at the need for a change in thinking with respect to the human factor, lack of intermodality, no sharing of resources, or the dominance of the automobile as the most popular mode of travel. It is significant that some interviewees are looking for a solution to the problem of environmental pollution only in the implementation of autonomous vehicles (not including the type of fuel).

This solution raises even greater doubts when one considers the problem of traffic jams and the lack of parking lots – only one of the participants in the debate pointed out that without changing the habits of residents in terms of mobility, it will not be possible to reduce congestion or the number of road accidents. Even if modern cars are replaced by electric and autonomous cars, but on a one-to-one basis – most of the problems faced by cities will remain unsolved.

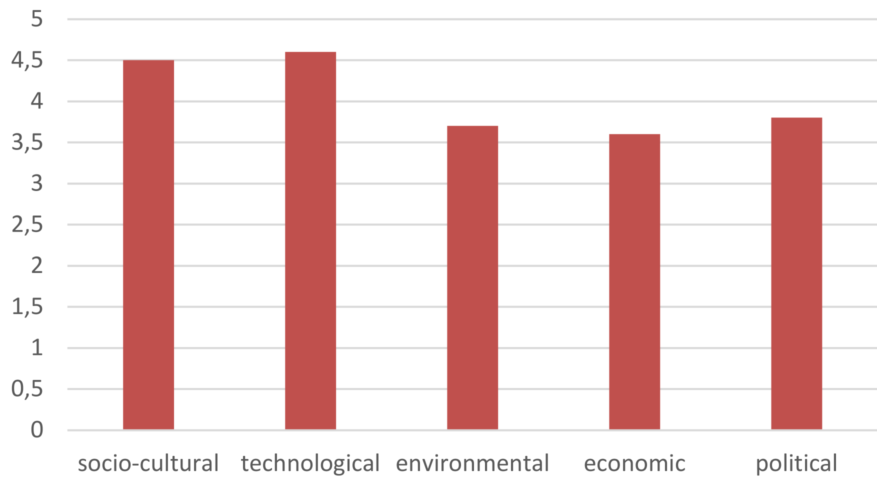

Figure 1.4. Key categories of threats to the implementation of smart mobility assumptions

6. Conclusions

The concept of smart cities in a simplified way consists in investments that are focused on sustainable economic growth of the city and improving the quality of life of the inhabitants. The most important thing is that they are to take place not only by the expansion of the broadly understood infrastructure (transport, ICT), but also one of the more important goals is to encourage the citizens living in the city to participate more fully in the life of the agglomeration.

On the side of factors favoring the implementation of smart mobility assumptions in the cities studied, the interviewees pointed out primarily environmental (climate crisis) and socio-cultural factors (in particular the feeling of a health threat and the desire to improve the quality of life, and openness to new, innovative forms of mobility). Unfortunately, political, economic and technological factors have been rated very poorly on the opportunities side, without which even the most aware local authorities will not be able to implement the concept of smart mobility.

In light of the literature review presented at the beginning of the article, in particular taking into account the leading elements constituting smart city and smart mobility, it is necessary to clearly emphasize the huge discrepancy between the theoretical assumptions and expectations of residents and city authorities and the technological possibilities of medium-sized urban centers.

The lack of financial support, as well as the lack of legal solutions and political programs conducive to new mobility, makes it impossible to take specific actions at the level of individual urban areas. Interviewees emphasized the gap between the largest Polish metropolises and medium-sized cities struggling with a shortage of finance and technological competence.

According to interviewees, there is a great need for in-depth research to identify the conditions for the transformation of current transport solutions to smart mobility. It also needs the identification of all stakeholders of this process and all data sources (ICT infrastructure and data analysis). It is equally important to conduct in-depth research as to the role of business entities in creating and stimulating the development of smart mobility while determining standards and minimum interoperability requirements.

The list of threats to smart mobility is consistent with these observations. By indicating the greatest threats, interviewees gave the highest importance to technological factors. In particular this included, the outflow of ICT staff to large cities, high technology competition on the international market (pressure on the costs of applied solutions, low profitability and low scalability of solutions and applications offered by local entrepreneurs) as well as the lack of a technical base (poor condition of technical universities). It is surprising, however, that despite indicating socio-cultural factors as an important element of opportunities, they also gave high importance to the analysis of threats (4.5/5), emphasizing above all the fear of a change in the scope of transport solutions used (reluctance to give up private transport) and lack of public confidence in modern transport solutions. In this case, it is difficult to count on the support of central authorities, legal solutions or changes in EU policy – the only key to overcoming these problems is local policy.

The high cost of changes in the area of city architecture, communication solutions, new investment, new vehicles, development of innovative, and a sustainable mobility system will remain a challenge for city authorities and local business. On the economic and political risk side, the interviewees indicated the cost of experts and programmers, low implementation rate and commercialization of innovative technologies, and funding for research in the field of smart mobility. They also cited a lack of incentives for launching commercial enterprises with a large "know-how" contribution and deficiency of units supporting researchers in obtaining/financing patents as well as lack of legal regulations allowing for quick technology implementation.

There are many attempts and projects implementing elements of a smart mobility, but there is a lack of extensive empirical and methodological research showing how to design and implement the transformation process. Deficiencies in the methodology of transformation constitute a particular obstacle in the opinion of representatives of medium-sized cities, deprived of access to funds similar to that of large metropolises, with a relatively poor network of ICT developers, experts and high-competent staff. The lack of modern technologies prevents the collection and processing of sufficient data, which is a condition for the development of smart mobility and the main factor in the process of maintaining the principles of interoperability, thanks to which it is possible to avoid unnecessary data redundancy while ensuring their integrity and consistency and ease of access and use.

Transformation process needs to be stimulated by business entities, supporting smart mobility development by providing modern solutions, generating new ideas, implementing technological innovations, investment financing, consulting and improving processes.

In future research, it would be desirable to target smart mobility experts in a wider range of fields, such as technology researchers, engineers, and frontline administrative officials related to smart cities. The leading indicators on the basis of digital data need to be developed to enable comparisons and progress to be measured.

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