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SMART CITIES

DEVELOPMENT AND TRENDS

Cases and research opportunities

HRZZ
Croatian Science Foundation

EF Split

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PREFACE

The content of this book is intended to contribute to the challenges of managing a smart city, technology acceptance issues, and new, underlying business models. The book provides theoretical and empirical underpinnings regarding the development and current trends of the Smart City concept alongside proposing future research opportunities.

Researchers agree that 5G technology and digital transformation are crucial for the development of smart cities and smart public administration. The concept of smart cities derives from the global trend of urbanisation. According to the United Nations Population Fund, the latest figures show that the population share in cities has doubled in the last few years and is expected to reach over 70% of the total population by the end of 2050. Consequently, cities need to cope with related and upcoming changes/challenges, while cities branded as “smart” need to keep or reach a high standard of quality of life for their citizens. With the popularisation of the Smart City concept and through the implementation of digital transformation projects in public administration, information services have radically changed, thus heavily impacting systems in an urban environment. In an effort to identify and explore the challenges as well as the potential and priorities for the implementation of smart city applications, cities often encounter complex problems, assuming considerable uncertainty.

Managing digitalisation is becoming increasingly demanding due to rapidly evolving innovations and the difficulty of managing the complexity of related technologies. However, these issues are not challenging only for organizations and individuals but for cities and local communities as well. Cities in particular are faced with major challenges arising from global shifts in the environment, rapid urbanisation and older infrastructure. As a result, several smart-city-related initiatives are emerging. Yet not all are successful. The book is thus focused on the analysis of new business models, technological innovations and their use related to the development of smart cities. After all, the spread of technology and the availability of automatically collected data create new opportunities for managing public services and creating new services.

The primary audience of this book will be students, academics interested in the Smart City concept, government organizations, managers, policymakers and strategic planners who intend to understand emerging digital technologies as well as their impact and applicability for cities. The book includes strategies for implementing and managing digital technologies together with a discussion on new business models. The chapters in this book are grouped into two parts: part one includes general theoretical and technical discussions of technologies and their benefits for modern cities, and part two includes use cases of different digital technologies and business models.

The Editors

PART 1

Definitions, concepts, research initiatives, worldwide examples and trends, theoretical modelling approaches, technical discussions, research directions

THE EMERGING WORLD OF SMART CITIES: DEFINITIONS, RESEARCH INITIATIVES AND WORLDWIDE EXAMPLES

1

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ABSTRACT

The introductory chapter of this book provides its readers with an insight into the Smart City concept as a viable solution to the challenges of the modern world. Its usage as an academic topic has increased over the last few decades, bringing new ideas into related fields such as sustainable and social development. In particular, the first part of this chapter focuses more on definitions and meanings behind the Smart City concept, determining the similarities and differences that they refer to. In the second part, the chapter puts forth a bibliometric analysis of the conducted studies in order to understand the state of the research field over the last 30 years. In addition, the most recent smart city trends alongside their practical implementation are presented. The analysed studies indicate that there are plenty of opportunities for testing and implementing advanced solutions to improve the quality of life in cities.

Keywords: Smart City concept, sustainability, social development, quality of life

1. INTRODUCTION

The rapidly increasing urban population is bringing about modern problems and affecting people's lives to a great extent. Fortunately, as the population grows and people migrate from rural to urban areas, technological advancement simultaneously increases and presents a potential way to face these issues. One potential solution is smart city development. The way smart cities are managed is through digitalisation since intelligent solutions are based on integrated sensor technology, connectivity, data analysis gathered from this connectivity and independent value-added processes. Digital transformation and connectivity are essential parts of a smart city as can be seen in successful examples (Gassmann, Böhm & Palmié, 2019).

There are different notions of smart cities, such as technological cities or digital cities. Thus, the primary focus is on the technical side of development. However, there are also some downsides to the technologically defined concept of a smart city. Incorporating and building technologies just for the sake of calling a city smart may cause overinvesting into technologies that do not improve citizens' lives. Therefore, the focus of smart cities should also be on a smart programme or the ability to assist city planners and the municipal authorities, based on technology, to achieve a higher level of efficiency as well as performance on different frontiers (Sharifi et al., 2021).

Transforming urban areas into successful and sustainable living settlements has been the goal of local authorities around the world for many years. Nowadays, there are a huge number of settlements or cities in the world that have decided to become so-called smart cities in order to achieve this goal of sustainability. Under the Smart Cities Programme, many government organizations are currently working to help transform cities and address well-being and sustainability, especially through high-tech solutions. Nevertheless, the notion of a smart city is ambiguous and the conceptual framework for helping cities and their administrations understand the broader picture of this urban development paradigm is limited. In this chapter, we thus present different smart city definitions, research directions and relevant underlying trends.

The aim of this chapter is to present smart city trends in research and practice. Definitions of a smart city are presented at the beginning, followed by research trends on the topic across different research areas. Further on, various examples of smart city solutions and case studies from cities around the world are described.

2. DEFINING A SMART CITY

The concept of smart cities appeared decades ago. Over the generations, the concept has been upgraded by introducing different innovations, which are currently being presented in third-generation studies. The emerging, new (fourth) generation is working to make all the elements of a city and its infrastructure (economy, transport, education, health, governance and others) "smarter". The development of the Internet of Things – integrated systems and their global integration – is creating new opportunities to build smart cities and move to a "smart economy" based on Industry 4.0, including creating production systems that are harmless to the urban environment. Digital technologies create the conditions for horizontal integration that go beyond "smart factories" and promote automated value chains at local, regional, national and global levels (Safiullin, Krasnyuk & Kapelyuk, 2019).

Although a well-established definition of a smart city does not exist, experts do agree that it is a solution to many problems that have occurred because of urbanisation (Silva, Khan & Han, 2018). Changes in the environment and society are forcing cities to rethink their infrastructure and governance. These changes arise mostly out of the fact that people seem to move from smaller villages to greater cities (Dameri & Rosenthal-Sabroux, 2014). This urbanisation trend can be seen all over the world, and it is expected to increase even further in the future (Laufs, Borrion & Bradford, 2020). The increasing population within cities leads to a variety of problems. Examples are traffic, increased environmental pollution, higher energy consumption and deciding how to deal with the increase in waste (Dameri & Rosenthal-Sabroux, 2014; Laufs, et al., 2020). Technological development in recent years has allowed city governments to tackle these problems by using ICT (Laufs et al., 2020). Naturally, as ICT enables the development of smart cities, most of the initial definitions of smart cities revolved around the usage of ICTs (Capdevila & Zarlenga, 2015; Laufs et al., 2020). Over time, these initial definitions broadened into a more holistic view, focusing on different aspects of smart cities. Besides the technological focus on ICT, smart cities were also based on the capabilities of the citizens (a human resource focus) or the cities' institutions' governance and policy.

A smart city is one that puts people at the heart of development, incorporates information and communication technologies into urban governance and uses these elements as tools to promote effective government formation, whichincludes participatory planning and citizen participation. By promoting integrated and sustainable development, smart cities are becoming more innovative, competitive, attractive and resilient, thus improving lives (Bouskela, 2016).

Smart city developments have proved to be a favourite when looking for modern solutions to challenges we face with urbanisation. Due to the challenges posed by urbanisation, the need for smart city initiatives is rising. It is projected that by 2050, more than 66% of the world population will be living in urban areas. As migration to cities increases, stress on the already-existing infrastructure will increase. This stress, in the long term, might affect future sustainable development initiatives, thus causing long-term social issues, waste management issues and energy consumption issues. Cities, which only make up around 3% of the entire land mass, use more than 75% of global resources and supplies and account for more than 80% of greenhouse emissions. Therefore, cities play a major role in social, economic and environmental issues, so it is essential to collectively establish solutions to modernise cities, leading them into a new era of sustainability and social development. Smart cities have emerged to be a modern solution to old problems (Praharaj & Han, 2019).

In recent years, research into smart cities has increased and the discussion on what constitutes a smart city has attracted attention in academic circles. Due to a vague definition of what a smart city constitutes and how it should be implemented in our society, different terms are sometimes used interchangeably. Terms such as "digital city", "smart community", "sustainable city", "intelligent city", "information city", "knowledge city" and "tech city" were all used in various applications to describe developments that could also be labelled with the term "smart cities". These different definitions support the fact that the term "smart city" is one which describes a broad array of different definitions and is a somewhat contemporary example of language use describing urban development management. The term itself originated in the 1990s but has become popularised and recognised because of its usage by several companies, mostly originating from the technological sphere, such as Cisco, IBM and Siemens (Praharaj & Han, 2019).

Despite several different definitions, there are commonalities which constitute a smart city. A city striving to become a smart city would possess the following important characteristics: (1) information and communication technology or ICT, (2) urban development led by businesses and entrepreneurs, (3) community development and social capital, (4) learning and knowledgebase development and (5) sustainability.

2.1. Information and communication technology

In order to enable stakeholder participation and manage large amounts of collected data, smart cities are using ICT to process and analyse critical information. ICT enables a city to improve the reliability, quality and performance of different urban services within it. ICT is also crucial when it comes to reducing resource consumption as well as different administrative and other costs. ICT works as a framework for many other smart city applications, where they work atop the ICT system. Smart cities are also using ICT to improve the lives and interconnectedness of citizens and other stakeholders (Praharaj & Han, 2019).

Without the usage of ICT, a smart city cannot exist. However, ICT cannot function alone and must be paired with intelligent city design, which will further provide robustness, scalability and flexibility to the network. In order to improve these network traits, a city can follow several different network designs. It is essential for a smart city to design and build autonomous and simplified networks that can be managed by a single controller, which reduces the complexity of the system and increases its efficiency. In order to further increase the robustness and flexibility of a smart city's network, a city should develop an automated threat detection system that will deal with different issues as they arise. The Internet of Things is also an integral part of a smart city, meaning that ICT infrastructure should be designed to integrate different IoT applications seamlessly. As cities grow, IT experts focus on scalability and redundancy of smart city solutions (Allied Telesis, n.d.).

This concept of "smartness" would not be possible without the rise of ICT. However, focusing only on the implementation of new technologies does not mean building a smart city. The utilisation of those technologies should help accelerate standard operations in cities while positively impacting the life of its citizens (Silva et al., 2018).

2.2. Urban development led by businesses and entrepreneurs

A vital trait of a smart city is its emphasis on business-led urban development, which shapes its growth. In most smart cities, businesses and companies are included in the process of designing a city. Otherwise, there can even be a crucial architect behind the developments. More and more cities are thus being shaped by corporations. This ensures the connectedness between the citizens of such a city and different corporations as they should echo stakeholders' interests (Praharaj & Han, 2019).

2.3. Community development and social capital

Within a smart city, its citizens must learn to use ICT and other technologies, adapt to new innovations and integrate them into their lives. This will allow a community to use new technologies to advance living standards, improve existing systems and design various different applications for new technology in different fields. In order to allow for such integration, communities must strive to increase their social capital, improving the relationship and connection between all residents (Praharaj & Han, 2019).

2.4. Learning and knowledge base development

Smart cities foster a high demand for learning and innovation, increasing the creativity of its residents. This allows for the existence of complex institutions of knowledge creation, knowledge management and infrastructure for communication (Praharaj & Han, 2019).

Infrastructure is an essential component that cannot be overlooked. However, public institutions and policymakers often overlook non-Internet-based technologies that could be used for building a smart city. Additionally, an often overlooked step is process mapping as well as understanding all the processes in the city, which is necessary for improving them (Baltac, 2019).

2.5. Sustainability

Smart cities invest in social development, infrastructure and ICT systems in such a way that they promote and allow for sustainable growth, increased quality of life and smart management of limited resources (Praharaj & Han, 2019).

3. SMART CITY RESEARCH – A BIBLIOMETRIC ANALYSIS

To better understand the state of research on the Smart City concept, a bibliometric analysis was conducted on Web of Science data in May 2022. Further on, a co-occurrence analysis of author keywords was performed on articles from 2012 to 2021 to examine what the main topics in smart city discussions are across various research areas, namely (1) computer science and information systems; (2) engineering and (3) the field of green, sustainable science and technology.

The results show that the smart city topic first occurred in 1991 but has not been studied extensively until the late 2010s. Specifically, until 2022, more than 80% of the total number of publications were published after the year 2017. The number of publications has been in decline since 2019 (see Figure 1.1).

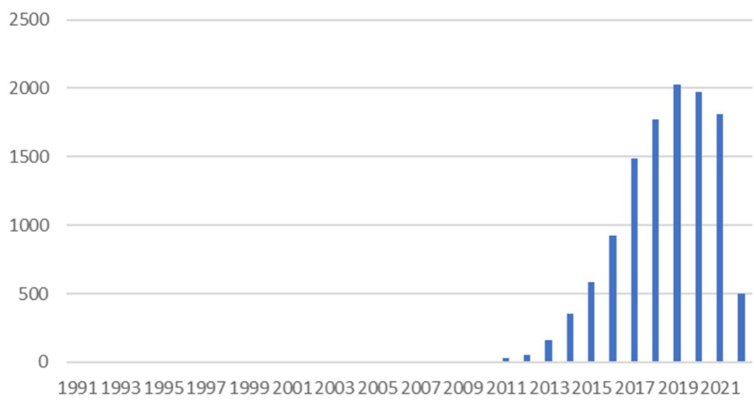

Figure 1.1: The number of publications on the smart city topic in the Web of Science database over the years

Most publications are either articles (48%) or conference proceedings (42%) (see Figure 1.2) from the fields of computer science, engineering and telecommunications, published by IEEE, Springer Nature and Elsevier. From that, it is evident that the most prominent disciplines covering the concept are technical since a majority of research has been done on the technological aspect of it. Furthermore, the vast number of conferences indicates the attractiveness of the topic. The main centres of smart city research are China, the United States and India, from where the majority of authors comes.

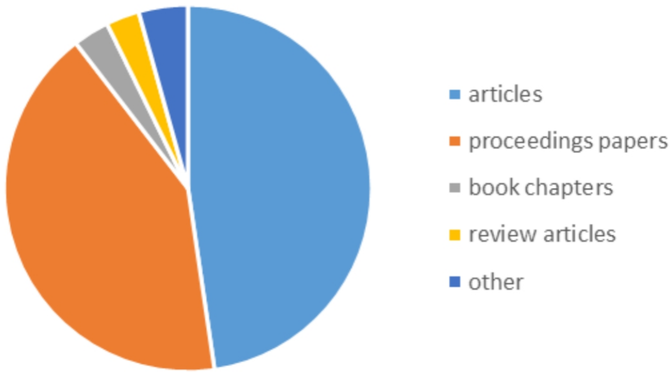

Figure 1.2: The share of publications on the topic of smart cities by type

The co-occurrence analysis was performed on author keywords on a sample of articles published between 2012 and 2021, including 5,492 publications. The sample was further divided into three subsamples by research areas of interest, since the main objective of the analysis was to find information on how research topics on the Smart City concept vary across research areas. The first subsample included 1,282 articles from the WoS category "computer science, information systems"; the second one included 1,813 articles from the WoS category "engineering"; and the third 535 articles from the WoS category "green, sustainable science, technology". The mentioned categories were selected with the aim of getting a more technological perspective, together with a sustainability perspective, since these are the main factors of the explored concept. For each sample, the co-occurrence analysis was performed excluding the keywords "smart city" and "smart cities", since they are related to all the other keywords.

3.1. Computer science and information systems

Figure 1.3 indicates that smart city research topics in computer science and information systems can be divided into five clusters, differentiated by different colours (yellow, purple, blue, green and red), with keywords within clusters of the same colour having great similarities.

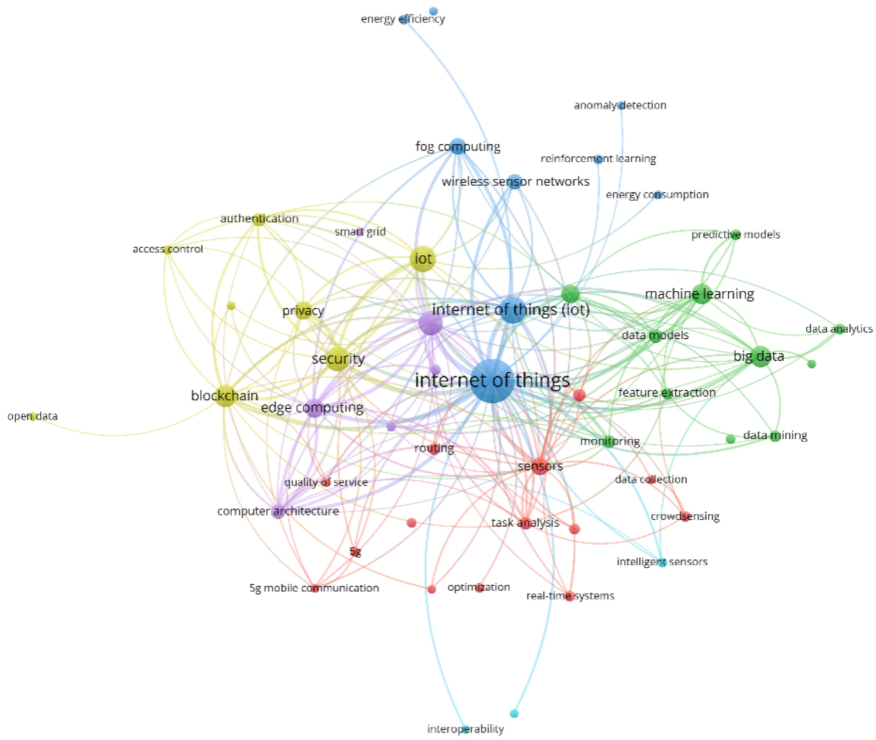

Figure 1.3: Keyword co-occurrence network of smart city research in computer science and information systems

The yellow cluster focuses on security and safety of blockchain technology and the Internet of Things (IoT). The blue cluster focuses on energy management and computing in IoT. The green cluster focuses on data analyses of big data. The purple cluster focuses on edge computing and computer architecture, whereas the red cluster focuses on the use of 5G, sensors and routing for data collection and optimization.

3.2. Engineering

Figure 1.4 indicates that the smart city research topics in engineering can also be divided into five clusters (yellow, purple, blue, green and red).

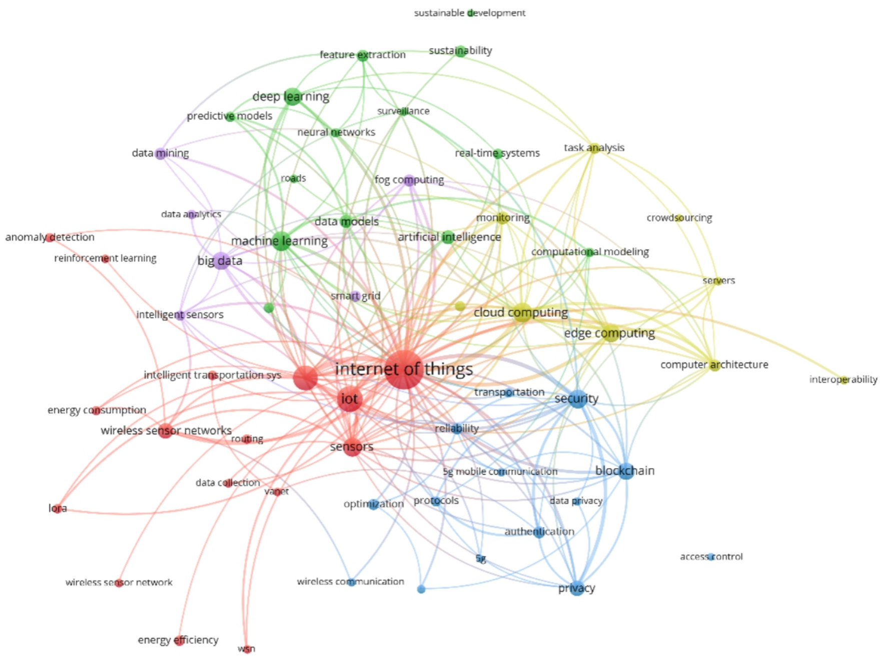

Figure 1.4: Keyword co-occurrence network of smart city research in engineering

The yellow cluster focuses on cloud and edge computing, allowing for interoperability and monitoring. The blue cluster focuses on security and privacy of blockchain 5G technology. The green cluster focuses on machine learning, deep learning, artificial intelligence (AI), together with sustainability. The purple cluster focuses on big data analysis and fog computing, whereas the red cluster focuses mainly on the use of sensors and energy management in IoT.

3.3. Green and sustainable science technology

Figure 1.5 indicates that the smart city research topics in green and sustainable science can be divided into nine clusters (yellow, purple, light blue, dark blue, pink, red, orange, brown and green).

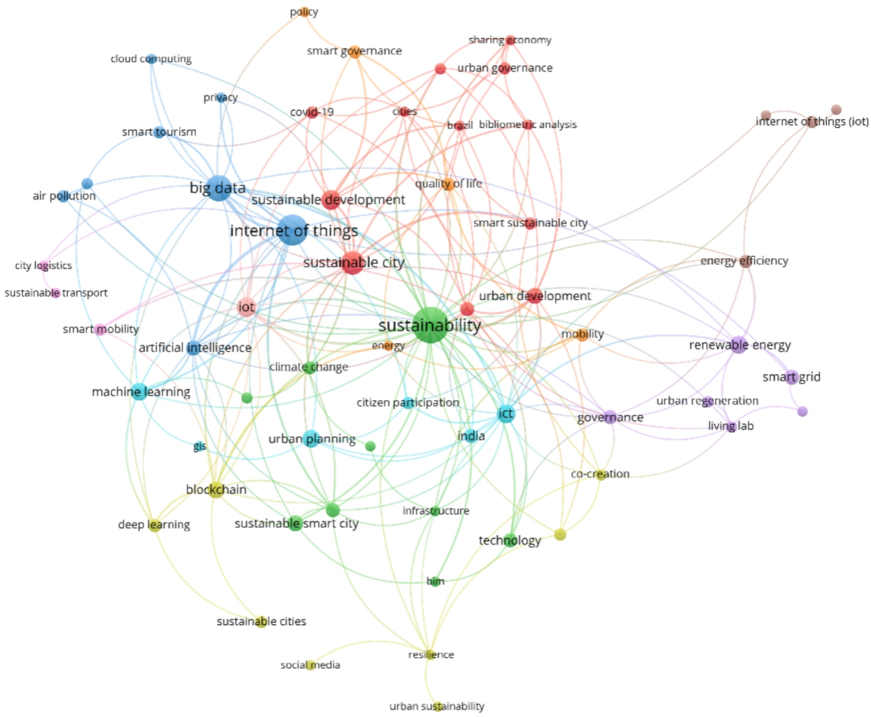

Figure 1.5: Keyword co-occurrence network of smart city research in green, sustainable science technology

The yellow cluster focuses on the use of blockchain technology and deep learning for achieving sustainability and resilience of cities. The light blue cluster focuses on urban planning related to machine learning and information communication technology (ICT). The dark blue cluster focuses on IoT, big data, AI, machine learning, cloud computing, etc. related to pollution. The green cluster focuses entirely on sustainability in smart cities related to climate change and technology. The purple cluster focuses on the governance of urban development related to renewable energy and smart grids. The red cluster focuses on sustainable development as well as government and sharing economy, similarly to the green cluster. The pink cluster focuses on city initiatives related to smart mobility and transportation. The brown cluster focuses on energy efficiency related to IoT. Finally, the orange cluster focuses on smart governance, mobility and quality of life.

4. CURRENT SMART-CITY - RELATED TRENDS

Cities are currently experiencing a revolution in terms of planning and what defines a good life for their residents. There are several trends which are crucial to understanding what direction city planning will take. Each city will have its own unique circumstances and technicalities, so, now, every trend can be utilised in every city. Different literature identifies different trends that cities might start implementing in the future or that are already active. Some of the most important and most commonly identified trends are briefly described below.

4.1. Green city planning

Heavily populated areas are usually defined by construction and high population density. Green cities are now pushing green planning as an alternative. This will increase the amount of green public space and residents' quality of life as well as help ameliorate the environmental impact of the city. A good case study would be Singapore, where the city has been completely transformed by planting trees, resulting in cleaner air. Spaces like these will also encourage outdoor activities amongst residents, such as cycling, walking and other types of sports. We can also observe that such spaces increase one's connection to nature and allow families to enjoy the outdoors and parks instead of spending their time at home. This type of planning also promotes a decrease in car-centric streets from which many cities, especially in Europe, are moving away (Neirotti et al., 2014).

4.2. Smart health communities

Cities are currently developing new types of healthcare systems that not only focus on immediate care, but also on prevention and post-care. It is essential that cities move toward prevention as this would greatly reduce the burden on medical facilities. Both mental and physical prevention is key to managing the well-being of residents, while better care facilities ensure that patients get the best care. To complete the cycle, cities must invest in post-care in order to transition residents back to their normal life as soon as possible and ensure their well-being in the long term. Cities are also teaming up with technology companies to develop health warning systems and management systems, allowing for better tracking of patient files (De Marco & Mangano, 2021).

4.3. The 15-minute concept

Many cities today are moving towards a concept called the “15-minute” city. With this design philosophy in mind, neighbourhoods are being designed so that amenities and different services are all within a 15-minute range and accessible either on foot, by bike or integrated public transport. This concept is better suited for bigger, more dense cities, particularly in Europe where many cities already implement this approach (Antunes, Barocca, & Guerreiro Oliveira, 2021).

4.4. Clean mobility

One of the first changes that came in the early 2000s was the introduction of smart maps, which provided the opportunity to monitor the condition of the roads in real time, enabling users to manage their own journey and avoid traffic. This change stimulates a more efficient and sustainable mobility system and decreases challenges that the previous condition of the roads caused: pollution, noise, congestion and an inefficient mobility infrastructure (Lyons, 2018).

Many cities today are working towards providing their citizens with clean, intelligent and autonomous mobility through more walking and cycling spaces and by providing transport as a service. Cities are striving to eliminate the need to travel. Within the concept of clean mobility, electrification plays a key role in vehicle sharing. Autonomous and electric mobility helps to eliminate congestion based on intelligent solutions in which data plays a pivotal role (De Marco & Mangano, 2021).

4.5. Inclusive services and planning

Cities are increasingly providing inclusive services and battling inequality by providing support for the most vulnerable members of society. Cities must ensure equal opportunities and equal participation in society in order to not exclude population groups and allow their members the opportunity to find jobs and become interconnected (De Marco & Mangano, 2021).

As companies are becoming customer oriented, they start to prefer services that are easier for the customers to use. The “as a service” concept is not new, but the terms “Mobility as a Service” (MaaS) and “Energy Efficiency as a Service” (EEaaS) have been coined recently and offer lots of potential in the transport of people and goods as well as cost efficiency in emissions reduction (Crowe, 2022).

4.6. Digital innovation systems

Systems like these allow cities to attract new talent, and enable greater productivity, creativity of the workforce and innovations. By fostering an open culture and creating an ecosystem of universities, companies, government and the public, cities will enable connections between innovators and allow them to tackle the city’s most profound problems (Antunes et al., 2021).

4.7. Circular economy

More and more cities are adopting new policies that foster the culture of a circular economy, allowing for the fair trade of resources as well as focusing on sharing and reusing resources. Such an economy also limits waste and focuses on local production facilities such as farming (Antunes et al., 2021).

4.8. Smart and sustainable infrastructure and buildings

In order to improve the use of energy, many cities have introduced the concept of the smart grid, which is an eco-friendly system that reduces the use of electrical resources. The system is based on two-way digital communication where data about consumption is collected, monitored and analysed in order to improve energy usage, which results in higher transparency, efficiency and lower costs (Tuballa & Abundo, 2016).

Cities are setting themselves goals of building sustainable structures, limiting energy loss and the usage of drinkable water, which is becoming more and more scarce. Waste is also a big consideration, and building proper infrastructure for disposal and recycling is key to achieving a net positive in terms of sustainability. The Net Zero Carbon Buildings Commitment was signed by 28 signatory cities and is aimed at reducing carbon emissions produced in the building sector (Antunes et al., 2021).

Utilizing the power of wind and other natural resources is already a familiar way of investing in clean energy to which most of the developed countries are dedicated. However, cities are starting to use technology in an even more efficient manner, such as monitoring energy use in real time and optimising energy consumption. The focus shifts to using sustainable and ethical materials in an effort to become socially responsible and environmentally friendly. In that regard, cities are using resources in the most efficient ways possible, mostly relying on renewable energy resources.

4.9. Public participation in city building

Cities are pushing to include their residents in more and more city decisions, giving them a sense of belonging and increasing the feeling of co-ownership. Through technology and open data, cities can ask residents to provide more information on what bothers them in the city and what might be changed. This gives cities a rough idea of the direction in which residents want the city to move. A good example of this is the city of Leuven in Belgium, where the authorities have already implemented a framework to collect citizen ideas on how to improve the city (Antunes et al., 2021).

4.10. AI operations

Automated technology is truly the driver of the future. Cities have begun to recognise this trend and are moving to implement such technologies in many of their systems. Services such as transport, public safety and infrastructure are being upgraded with the help of automation. Cities are implementing central systems, which control many aspects of the city, removing the need for planning by human controllers and allowing for systems to be controlled by AI technologies instead. A good example of a city that is trying to implement such a system is Cascais in Portugal, where they have developed a managed command centre (Neirotti et al., 2014).

4.11. Cybersecurity and privacy

At this time, cybersecurity is becoming ever more important. Cities manage enormous amounts of data, which must be kept safe. It is essential that preventative measures be developed that can protect these data vaults. Thus, cities are investing more and more into security. As cities digitalise more, and more systems become digital, the chances of a cyberattack disrupting infrastructure and basic utilities grow. Citizens of such cities are being taught the value of data privacy, so cities must think carefully when managing sensitive data. A good example of a city following this trend is Tel Aviv, where, because of an increasing number of cyberattacks, they have started to develop more and more advanced countermeasures (Neirotti et al., 2014).

More ransomware attacks are also expected to happen on a global level. Immense pressure will be put on governments to build resilient cybersystems to have a strong defence against any cyberattacks. The focus should thus be on data protection, frequent system backups, building cybersecurity contingency plans and cybersecurity education (Musulin, Teale & Crowe, 2021).

4.12. Surveillance and policing through AI

Cities are using the power of AI to ensure the security, safety and well-being of their citizens and, all the while, safeguarding their privacy and human rights. The upside of this technology is that it can prevent many crimes and also help detain offenders after a crime has been committed. However, this trend is still very controversial as it can be seen as an invasion of privacy. Such AI accurately predicts if a person has committed multiple crimes by comparing data from different crimes. These types of controversial systems can already be seen today, especially in China, where the government is using AI systems to monitor their citizens (Antunes et al., 2021).

5. CASES OF SMART CITY IMPLEMENTATION

5.1. Dubai

Dubai's mission was to improve the quality of life and increase the happiness of its residents and visitors through a rapid adoption of digital innovation to make the city more sustainable, inclusive and safer, as well as enhance people's experience in it (Dassani, Nirwan & Hariharan, 2015). A big reason for Dubai's success in the transition into a smart city has been a high and increasing dependence of its population on personal devices. Privacy may pose one challenge, since there is a necessity for cities' creation of privacy governance policies that clearly state what data can be collected and stored, and who can have access to it (Dassani et al., 2015).

Dubai has its own office for digital transformation, namely Digital Dubai (Digital Dubai, 2020). More than 130 projects and partnerships with governmental and nongovernmental organizations have been launched within this office. Their key initiatives include a data initiative, a blockchain strategy, a happiness agenda, an artificial intelligence plan, start-up assistance and a paperless strategy. The data initiative and start-up assistance are additionally described below.

The main purpose of the data initiative is to increase smooth accessibility and exchange of location data, improve data management and coherence, and establish a strong data community. Data is used for (1) measuring the social happiness index with the help of AI; (2) visualizing electricity and water consumption in urban communities; (3) a food inspection dashboard to help inspectors plan inspection locations, frequencies and results with a visual display; (4) observing urban flow as the population changes and moves, which is invaluable for urban planners, government entities and real estate developers.

Eventually, Dubai Data wants to become an impartial market data intermediary in the city and create an open and well-regulated market, where the value of data is realised and used to trigger new opportunities.

Start-up assistance refers to the Dubai Smart City Accelerator, which is a leading accelerator supporting innovative businesses in areas of the Internet of Things and Connectivity, Urban Automation, Mobility, Artificial Intelligence, Sustainable Cities, Smart Government and the Smart Retail Industry. With this initiative, the focus is on looking for innovative solutions to help make cities smarter and overcome important challenges due to congestion, waste and energy in order to improve people's quality of life.

The Digital Dubai initiative is implemented through a large number of technology-supported applications that residents and visitors to the city can use on a daily basis to make life easier and better. These include Dubai Now, Rashid, Dubai Pulse, Dubai Careers, Smart Employee, Happiness Meter and many more.

For example, Dubai Now is a government application that is meant to provide access to 120 public and private sector services. The goal is to offer everything in one place, including (1) bill payment; (2) everything related to driving (parking fees and fine payments, driver's license renewal, car registration, car sales and purchases, car insurance, up-to-date traffic data, etc.); (3) housing-related activities (paying water and electricity bills, data on water and electricity consumption, viewing real estate, ordering services for the home, visa arrangement, etc.); (4) health (viewing and managing medical examinations as well as results and prescriptions for medication, finding doctors, etc.); (5) education (school options, signing contracts between parents and schools, etc.); (6) security (requesting police certificates, searching for the nearest station, checking the status of cases in court, etc.); (7) travel (flight information, lost and found, and so on); (8) Islam (daily prayers, nearby mosques, etc.); and more (donations, a calendar of events in Dubai, and the like).

5.2. Amsterdam

Amsterdam's smart city journey began in 2009 when the city of Amsterdam launched a programme called "Amsterdam Smart City" with the goal of reducing CO2 emissions by 40% by the year 2025 (Danielou, 2014). The Amsterdam Smart City programme is an open, community platform with which Amsterdam aims to connect and bring together all of the different stakeholders so that they can more easily share their knowledge, expertise, ideas and projects (Deskos, n.d.). In the beginning, the Amsterdam Smart City project covered five areas on which its incentives would focus. Yet, over the years, it has expanded the list to eight categories: big and open data, smart society, smart mobility, smart living, smart areas, smart economy, living labs and infrastructure (Brokaw, 2016). The Amsterdam Smart City programme works as a kind of catalyst, whereby it gathers projects and ideas and helps the better ones grow faster and larger. Over the years, it has launched several hundred projects of which many could theoretically be replicated and implemented in other cities around the globe. The programme's success exceeded all expectations, with Amsterdam winning the title of Europe's Capital of Innovation, granted by the European Commission in 2016 (Deskos, n.d.).

One of the more famous projects started by the Amsterdam Smart City platform is the "Climate Street" or Klimaatstraat. With this project, Amsterdam aims to be among the top sustainable cities by 2040. In this street, 40 entrepreneurs work on different solutions and fixes on how to reduce CO2 and NO2 emissions in their street – such as smart lights, smart cooling and heating systems and other solutions – which will later be transformed and implemented to fit cities all across the Netherlands, not just Amsterdam (Veen, 2016).

Amsterdam has definitely solidified its position not only as a smart city but also as a leader in terms of innovation in the field of smart cities, with the move to make all its city data open source, meaning everyone could access it and add onto it to improve it even further. This could be done by using smart meters to remotely regulate house energy consumption in real time, making countless improvements to support public transport, using electric vehicles as well as by strengthening the already-existing cycling culture in Amsterdam and the Netherlands, using new sources of renewable energy production and in many other ways (Brokaw, 2016; Danielou, 2014; Deskos, n.d.).

With its fast population growth and numerous tourists, the city can get very crowded and unsafe. The Public Eye project is a smart city design that uses Artificial Intelligence and city cameras to monitor crowds in public places. It can predict the size, density and speed of crowds and send staff to intervene if a risky situation presents itself. During the pandemic, Public Eye was also used for measuring social distancing between people. Traffic lights were positioned outside facilities to let people know when they are full, and LED strips were used to keep people at the recommended distance in public areas. As for privacy concerns, the developers have stated that the camera footage is not being saved nor recorded, and the system is open source, meaning that anyone has access to it and can analyse the algorithm behind it. The reason for its placement is stated under every camera (Wray, 2021).

5.3. Barcelona

Back in the 1990s, Barcelona developed and presented its Smart City Strategic Plan, which was intended to make the city the leading smart city in Europe. Barcelona was suffering from enormous infrastructural problems due to a high level of urbanisation, dense construction in the city and, at the same time, weak urban planning. Additionally, there have been multiple economic crises in the region during that time, and Barcelona was preparing to host the Olympic Games in 1992. Therefore, a strategic plan and smart city initiatives were more than necessary. They were intended to address and improve the previous poor planning with regard to housing, environmental issues, water, transportation and energy (Bakıcı, Almirall & Wareham, 2013).

Like many other smart cities around the world, Barcelona invested heavily in ICT infrastructure and IoT networks, especially in the early 2010s. Through a new technological infrastructure, Barcelona created citywide sensor networks that collect data on energy, the environment, transport and so on, to provide instant feedback on, for example, air quality, waste management, noise, public transport options, parking spots, etc. (Bibri & Krogstie, 2020). The aim of the democratisation of Barcelona's ICT infrastructure is to provide opportunities for citizens to test and try out the technologies and to get feedback on what is useful and what might be a failure for urban development. When citizens are more technologically literate, they better understand how and when technologies can be useful (Urban Hub, 2018).

But what makes Barcelona's smart city initiatives distinct is the so-called Smart City 3.0 approach, which is mainly about the strong inclusion and participation of its residents. In 2015, the city of Barcelona switched its focus from a top-down approach towards a more citizen-centric one. In doing so, Barcelona has taken different actions. First, a new data infrastructure has been developed, consisting of three components: Sentilo, an open-source-based data collection and sensor platform; CityOS, another open-source platform for analysing data; and various service apps at the UI level that facilitate access to all data. Second, this integrated control serves to democratize data. For example, the new platform and all the data it contains belong to the city. It can be used by citizens, private companies and other interested parties; however, the city and its residents remain the true owners and decide on access and privacy (Smith, 2018).

Thus, it seems that Barcelona's smart city approach is really citizen centric already at its core. Instead of just transforming the city in a top-down manner, the government aims to integrate its inhabitants into the transformation process and simultaneously prepare them for the challenges and opportunities of the 21st century, thereby acknowledging that a smart city can only develop in both directions – top down and bottom up – and that it is not viable without its smart citizens. Social inclusion is thus the focus of Barcelona's approach (Noori, Hoppe & de Jong, 2020).

There is a smart waste collection system in place in Barcelona. The system works with the help of special ultrasonic sensors, which are placed within bins and show to what degree they are full. Consequently, sanitation workers can plan their routes based on the sensors; they can empty the full bins that are along their route first. This reduces time spent on collecting waste, which additionally decreases fuel costs. Some bins are also directly connected to underground repositories, which allow waste to be vacuumed out using underground pipes and then incinerated. The energy that comes from this waste incineration is further used for the city's heating system (Bibri & Krogstie, 2020).

5.4. Helsinki

Over the years, Helsinki has shown commitment to fighting climate change through building smart energy solutions. Its smart buildings system has been a good example of a collaboration between cities and businesses aimed at creating a more functional and climate-neutral environment for citizens. Smart buildings systems can recognise where energy is wasted and how it can be saved, which noticeably increases buildings' energy efficiency. The city is promoting its strategy to local businesses and building a supportive environment, which can enhance collaboration. Opening data to public use must be seen as beneficial for all stakeholders and not as a tool for governmental control. Hence, security-related issues must be thoroughly considered. The city thus supports the goal that all smart solutions must be developed in respect to the security and privacy concerns of all stakeholders in the city. It is achieved through many consultations between lawyers and different city organizations (Hämäläinen, 2020).

The Helsinki model includes open data, interfaces, innovation, the ecosystem and public–private cooperation. Most of the operators and transportation companies have allowed access to their data. Helsinki Region Transport (HSL), as a local public transportation authority, has opened access to all the relevant data about routing, maps, timetables and vehicle locations, which can be used by everyone. Besides the fact that Helsinki was ranked the leading city in the implementation of MaaS in Juniper Research's 2018 study, it is highly ranked on lists for air quality, congestion, bicycle use, mass transit use and cost of single public transport tickets as well. Helsinki Regional Transport's ambitious target and vision is for public transport to be the number one choice for travel. The plan is for 30% of buses to be running on electricity, which would be generated in a sustainable manner (for example, using wind, hydro or solar energy), by 2025. In order to complete that vision, the city has set some goals, such as smooth journeys, clear services, increasing public transport use, compact and attractive regions, fewer emissions and effective finances.

5.5. Copenhagen

Copenhagen aimed to lead the way in reducing carbon emissions and energy consumption through intelligent solutions in waste disposal, lighting and air quality (Tomás, 2017). The key smart city initiative for Copenhagen was the Danish Outdoor Lighting Lab. The initial aim of the lab was to test LED solutions for energy efficiency. But, eventually, it incorporated other smart city solutions in the field of mobility and parking, environmental monitoring, waste management, the Internet of Things communication systems and many more (Hansen, 2020). The Lab collects data throughout the whole city and makes a connection within its infrastructure. It therefore helps the municipality monitor and optimise smart city solutions in real time to meet citizens' needs. The living lab enabled the city to start its plan of reducing carbon emissions and energy consumption. The municipality had to monitor emissions and their sources, and they used the lab's data to do this.

In 2009, the municipality decided to go ahead with its plan to become a carbon-neutral city by the year 2025. This means not only reducing and finally eliminating emissions within the city of Copenhagen, but also outside its geographical boundary (Damsø, Kjær & Christensen, 2017). The energy sector contributes the most to emissions, but it also has the largest share of initiatives and the most impact on climate action plans (CAPs). The first CAP focused on improving the district heating system and promoting the wind power expansion. Artificial intelligence was used to predict when and how much heat and ventilation municipality buildings would need. CAP also promoted alternatives to using fuel in transport, such as switching from coal to biomass. The city set up electric chargers and established a natural gas as well as a hydrogen gas station and started switching to alternative fuels in the entire municipal fleet.

The city also collaborated with Google to start measuring the air pollution down to the street levels in the Air View project. A Google Street View car, equipped with air quality measuring equipment, built a precise air quality map of Copenhagen's neighbourhoods. It showed that the main roads have, on average, an ultrafine particle concentration in the air that is several times higher than the residential areas with less traffic. The city is now using this data to design future neighbourhoods in a way that will keep schools and playgrounds, as well as bicycle and walking routes, away from highly polluted roads. It will also allow the data to be used to foster more sustainable transportation (Utrecht University, 2021). For the same reasons, the city of Copenhagen established five measuring stations around the city in areas characterised by heavy traffic.

In terms of waste management and utilization, Denmark has been a forerunner in diverting municipal waste from landfills; its waste management system is almost completely designed around burning waste for energy. The city of Copenhagen introduced some new initiatives to increase plastic collection and separation to remove fossil-fuel-based waste from incineration giving the opportunity to each household to sort out the hard plastics from their waste (Damsø et al., 2017).

Several initiatives were also introduced to help prevent food waste. The city opened social supermarkets, the shops that sell food surpluses and goods that can no longer be sold because of overdue “best before” dates, incorrect labels, or packaging being damaged in different ways, although the food in these markets is still edible and safe to use. Consequently, in 2016, they introduced a social supermarkets application for mobile phones named “Too Good to Go”. The app connects its users with stores, restaurants and bakeries in their area that sell their food surpluses at reduced prices (Ghafoor, 2021).

6. CONCLUSION

The share of the urban population in relation to rural areas has been rapidly increasing in the past few decades and will continue to increase. Most of the population is already living in urban environments, which has been causing various issues. Cities are using digitalisation as a tool for effective and efficient planning, managing, and governing by implementing smart initiatives. Moreover, they are taking into account international and national policies and adapting them to the local context. In the past decade, there has been a tremendous growth in interest within the international research community for complex urban questions, arising from the challenges that go hand in hand with urbanisation. New disciplines emerged, exploring innovative approaches to overcoming the previously mentioned challenges by implementing smart initiatives. The Smart City concept has evolved alongside concepts like sustainable or green cities as a new managerial approach. The understanding of the Smart City concept was first limited to the digitalisation of city processes but has, in recent years, highlighted the importance of sustainability with the aim of providing good quality of life for its residents. This new perspective placed the responsibility on cities to help solve the environmental crisis happening worldwide, since they are one of the biggest producers of harmful greenhouse gases, together with agricultural activities and forestry. To conclude, even though smart cities have been extensively researched in recent years, there are still many perspectives that have not been covered yet. Moreover, case studies show that there are many challenges remaining in practice as well, which creates numerous possibilities for further research of the concept.

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ANTICIPATORY GOVERNANCE AND FORESIGHT: A STATE-OF-THE-ART REVIEW AND IMPLICATIONS FOR URBAN DEVELOPMENT

2

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ABSTRACT

The following chapter outlines the main principles of anticipatory governance and foresight alongside their implications for urban development. Besides the broad context and evolution of these terms, this chapter also observes and concisely discusses future research directions as well as actions. The main obstacle and challenge for this analysis is bridging the gap in the research literature between anticipatory governance practices and smart city concepts. Although both approaches are widely recognised, anticipatory governance and foresight methods are often overlooked in favour of the preferred Smart City concept. The proposed solutions for overcoming the mentioned gaps, which would lead to more foresight studies, include scenario-building studies within higher-education and public institutions, followed by building and testing the impact indicators to measure anticipatory governance benefits. As the research for this book was conducted within higher-education institutions, the authors propose developing a scenario-exploration foresight system for urban development among graduate students at the Faculty of Economics, Business and Tourism in Split, Croatia.

Keywords: anticipatory governance, foresight, urban development, scenario-exploration system

1. INTRODUCTION

In today's world, the only continuous thing is change. Change can happen slowly, over a certain period of time, but can also happen rapidly and unpredictably; their speed of occurrence, intensity, predictability and effects may vary significantly on all levels, including local and global ones, in governmental and corporate environments. Governments and governmental institutions have identified a need to prepare for future changes, which can bring threats and opportunities (Ramos, 2017). For this reason, they have increasingly started to (re)consider the future in their policy- and decision-making.

Focusing on cities, it is important to create agile city policymaking in order to deal with any occurring and future changes, which are difficult to foresee. Ramos (2014) and other authors find it crucial to factor complexity into future studies' approaches. The systematic use of foresight is essential to understanding and introducing changes. Implementing this approach at a practical level would allow cities' policies to be proactive, adaptive, and driven toward a preferred future as opposed to being reactive and misguided (Ramos, 2017), that is ones in which future happenings are not considered.

Foresight as future intelligence gathering (Kienegger, 2015) needs governance and has been tested and combined with different approaches and traditions (e.g. technological forecasting or anticipatory democracy) that link foresight and governance (Ramos, 2014). The latest solution, according to the most recent literature, is found in anticipatory governance, which seeks to understand and shape the changes expected in the future by incorporating knowledge about the future into policies and decision making, thus aiming to proactively impact the long-term implications of its policies and decisions. Citizens' involvement is crucial in creating a knowledge base that can raise awareness of changes (Ramos, 2014).

Anticipatory governance is a relatively novel and under-researched concept, as can be seen in the results of the below Scopus database search done in March 2021 for "anticipatory governance" within article titles, abstracts or keywords. A total of 37 results in three subject areas – Business, management & accounting; Economics, econometrics and finance; and Multidisciplinary studies – shows that this topic has been insufficiently explored by researchers in these disciplines, as opposed to 142 results incorporating all subject areas (including biology, mathematics, technology, etc.). Figure 2.1 shows the rising trend in anticipatory governance research in recent years.

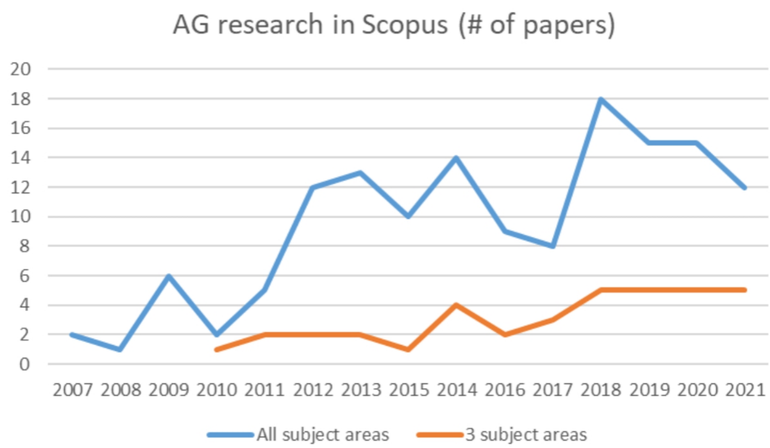

Figure 2.1: Number (#) of research papers in the Scopus database on the topic of anticipatory governance (made by the author)

The purpose of this chapter is to present an overview of the anticipatory governance and foresight research through a state-of-the-art review of its definitions, forms, tools and practices, with a special focus on implications for cities i.e. urban development.

The need for this study can be found in the necessity to bridge the gap in the literature by focusing on anticipatory governance, a type of governance that includes foresight and citizen participation. The topic is often overlooked because of the popularity of the smart city governance concept, which, in comparison, is overly technocratic (Ramos, 2017). Smart city management is more than twice as popular. The popularity of the concept can be observed by the Scopus database search conducted in April 2021, which brought 321 results in all areas and 51 results in three previously selected areas as described above. Although smart city governance means “better outcomes and more open governance processes” (Meijer & Rodríguez-Bolívar, 2016, p. 392) by means of new information and communication technologies (ICT) as well as human collaboration, it neglects to incorporate the future dimension in its planning processes, unlike anticipatory governance.

The aim of the study includes:

- Defining anticipatory governance (AG) in a broad context.
- Explaining the evolution of the term AG as well as its preceding approaches and components.
- Presenting foresight and identifying (participatory) foresight methods, which are important to the urban development context.
- Discussing and identifying future research directions of the topic, with a special focus on urban development implications.

The other sections of the chapter are organised as follows: section 2 provides a historical overview and brief evolution of the anticipatory governance research; it lists various definitions formulated by previous studies, AG components and founding concepts. Section 3 introduces foresight and its most common methods while focusing on participatory methods used in an urban context. Section 4 discusses institutional use of anticipatory governance and foresight, simultaneously describing recent governmental and EU institutional agendas for policymaking. It also introduces AG and foresight implications for urban development, along with possible future actions and research. Section 5 concludes this chapter.

2. THEORETICAL BACKGROUND: DEFINING ANTICIPATORY GOVERNANCE

2.1. Historical development and evolution of the anticipatory governance research

To get a better understanding of the term "anticipatory governance", its genealogy is to be studied. The word "anticipation" originates from the Latin prefix ante-, meaning "before", as well as "concerning position, order, or time". The Latin word capere means "capable", "capacity", "to take into possession". For this reason, practice i.e. exercise is central to anticipatory governance (Guston, 2014) as anticipation is about practicing/exercising a capacity for future purposes. However, according to Guston (2014), anticipatory governance is more than practice as it includes three different capacities, defined by Barben et al. (2008). These are (1) foresight as a pluralist approach that seeks multiple futures, (2) engagement as encouragement of the exchange of ideas between different stakeholders, and (3) integration as overcoming the divide between stakeholders and creating opportunities to develop long-term capacity building.

The year 2001 marks the emergence of two strands of literature on anticipatory governance. The first one is related to public administration and management (e.g. Bächler, 2001, as noted by Guston, 2014), and the second one is related to environmental studies (e.g. Gupta, 2001, as noted by Guston, 2014). From this point onward, research expanded significantly to other strands of literature, including research and innovation in general (e.g. Gudowsky & Peissl, 2016), emerging technologies (e.g. Sarewitz, 2011), genetics (e.g. Conley, 2020), nanotechnology (e.g. Wiek et al., 2016), automated vehicles (Milakis & Müller, 2021), climate (e.g. Serrao-Neumann et al., 2013), robotics (Diep et al., 2014), and so on. Lehoux et al. (2020) discuss the responsible research and innovation (RRI) field of research, which also implements future-oriented anticipatory forms of governance in order to analyse the benefits and risks of innovations.

2.2. Exploring definitions of anticipatory governance

Several definitions of anticipatory governance have been found while reviewing the literature, showing the different terms and descriptions used to describe the core features of anticipatory governance. Before discussing them, it is interesting to address the necessary qualities of anticipatory governance: open-mindedness, curiosity and constant questioning of assumptions, as well as willingness to examine alternative possibilities (Fuerth, 2009).

The Institute for the Future (2020, p. 1) brought forward some of the meanings of AG in 2020, which, for some, signifies “incorporating forecasting, visioning, and participatory processes when setting public goals, engaging government institutions in committing to those goals, and measuring progress against them”. For others, it signifies “setting up rapid feedback loops between technical innovations and their social and environmental impacts to influence future development decisions in both academia and corporate R&D.”

According to the definitions listed in Table 2.1 below, anticipatory governance is, at the same time, a process and a system that uses foresight and other forms of anticipation processes in developing different actions and responses to future events. The role of foresight in the definitions is emphasised as an important tool, which collects emerging knowledge that is to be used later by AG in the processes of policy- or decision-making.

Table 2.1: Definitions of anticipatory governance

Definition	**Author**
"A broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible".	Guston, 2008, p. 6
"Anticipatory Governance is a system of institutions, rules and norms that provide a way to use foresight for the purpose of reducing risk, and to increase capacity to respond to events at early rather than later stages of their development."	Fuerth 2009, p. 29
"Anticipatory governance is a mode of decision-making that perpetually scans the horizon for changes demanding adaptation in our plans and behavior. It can be regarded as a scalable system of systems, in which foresight is integrated at every level."	Fuerth, 2009, p. 30
"Anticipatory Governance denotes large scale participatory processes and systems for exploring, envisioning, direction setting and developing a strategy for a region."	Ramos, 2017, p. 1

Source: compiled by the author

In its publication, OECD, the Organization for Economic Co-operation and Development (2019), mentions a new type of AG – anticipatory innovation governance, which is defined as the "broad-based capacity to actively explore options as part of broader anticipatory governance, with a particular aim of spurring on innovations (novel to the context, implemented and value shifting products, services and processes) connected to uncertain futures in the hopes of shaping the former through innovative practice" (OPSI, 2019). Anticipatory innovation governance is innovation-oriented with a narrower scope than AG in general.

2.3. The anticipatory governance system and its foundations

This subsection explains the core components and functioning mechanisms of anticipatory governance. According to Fuerth (2009), anticipatory governance comprises four basic components: *a foresight system*, *a networked system* for integrating foresight and the policy process, *a feedback system* to evaluate its performance and manage institutional knowledge as well as an *open-minded* institutional *culture.*

Anticipatory governance is a scalable process transferable to every level of governance (from local to global) as it contains similar relationships on all levels. It represents the environment, with characteristics that include the interaction of its subsystems for the purposes of foresight, networking and feedback (ibid.). Fuerth (2009) tried to summarise AG operations into the following activities: (1) supporting foresight by encouraging networking between public and private organizations employed to unify forecasting, futuring and modelling; (2) employing specialised systems to identify and track signals of change; (3) evaluating these signals and incorporating them in the development of alternative scenarios and simulation testing to see if they should be included in policies; (4) using feedback systems for a re-examination of policies, developing networked processes for collection, assessment and analysis of intelligence.

Although the first concepts of AG date back to 2001, its foundations are found in the following seven traditions and discourses identified by Ramos (2014). These traditions also present a background for designing anticipatory governance strategies via a service design approach, which enables adaptation to diverse needs and situations (ibid.).

1. Science, Technology and Innovation Foresight (STIF): includes priorities such as policy formulation, strategy and priority setting, cooperation and networking, generating visions of the future, promoting public debate, identifying key barriers and drivers of STI, encouraging strategic and future thinking.

2. Anticipatory Democracy (AD): developed in the 1970s in the United States to engage citizens and other community stakeholders in processes of policy development, together with policymakers in the context of emerging futures.

3. Futures Commissions (FC): semi-independent research institutes/agencies established to provide a foresight function for both government and the public, which consequently can influence policy development.

4. Foresight-informed Strategic Planning (FISP): participatory planning that engages key stakeholders in discussions of the long-term issues that are being mutually experienced (this includes methods such as search

conference methods and scenario planning).

5. Transition Management (TM): a long-term, systemic strategy for reaching sustainable development goals and visions.

6. Integrated Governmental Foresight (IGF): integrates intelligence and foresight activities across governmental departments, joining synergies and similarities in regard to systemic policies.

7. Network Foresight (NF): includes the usage of ICT systems on interactive web platforms, which are generally accessible to everyone interested and capable of contributing.

3. FORESIGHT

As noted in section 2.2, foresight is a central part of anticipatory governance. In an attempt to back up this thesis, additional text mining of AG definitions and components was done when trying to create an AG word cloud. From the 255 words that were analysed (with a minimum of two frequencies being set), the word “foresight” turned out to be the most common (#14) as shown in Figure 2.2.

Figure 2.2: Word cloud for anticipatory governance (author's work in the software WordItOut)

According to Fuerth (2009), foresight is the capacity to anticipate alternative futures and ability to visualise their multiple outcomes in the form of consequences. It is a way to visualize, run through and improve actions without testing them in reality, where the consequences of errors are serious and irreversible (ibid.). According to the same author, the purpose of foresight (as a part of governance) is to enhance the ability of decision-makers to prepare for long-term events for the benefit of citizens.

Foresight studies are often complicated, require many resources – including financial ones – and aim to provide important information to the government, industry and academia for technology planning and knowledge expansion (Gibson et al., 2018).

The concept of foresight is often confused with the concept of vision, but the two differ significantly. Vision is likely to be seen as a fixed image of the future, while foresight is conditional and subject to change as it presents a continuous effort to show different possibilities of the future, which helps in making decisions (Fuerth, 2009). Foresight-practitioners welcome alternative perceptions of the future as essential resources, unlike vision-makers who tend to create unique visions (ibid.).

According to Gibson et al. (2018), there is no unique framework for developing and planning foresight activities. However, according to Foresight futures (2021), the first step in exploring possible futures starts with defining the foresight framework – a structure that encourages generating different perspectives to seek new threats and possibilities within external changes, to prepare new policies and strategies for generated futures and to decide on the action to take today to prepare towards a preferred future. The generic foresight process framework developed by Voros (2003) consists of inputs, analyses, interpretations, prospection, outputs and a strategy/policy. Another framework found in the literature is presented by Keenan (2007) and includes five mental stages of foresight: understanding, synthesising models of the future, analysis and selection, transformation and, finally, action. The last framework, identified by Inayatullah (2008), has six pillars of future thinking for transforming: mapping, anticipating, timing, deepening, creating alternatives and transforming.

3.1. Foresight methods

According to EC (2020), foresight is a discipline of "exploring, anticipating and the future" that helps in building and using collective intelligence in "a structured and systematic way to anticipate developments and better prepare for change". Foresight employs a vast number of methods that can be chosen, adapted and personalised according to the specific type of foresight and practitioners' choices (Kienegger et al., 2015). Unlike foresight, a specific set of methods for "anticipation" is not currently identified and available (ibid.). However, some authors (e.g. Gudowsky & Peissl, 2016) find forward looking and participation to be essential tools in actively and responsibly governing innovation, with a goal of developing sustainable, long-term strategies that include socio-technical changes.

The Practical foresight guide (Jackson, 2013) and Foresight methodologies guide (UNIDO, 2004) list and describe the most commonly used methods, which include brainstorming, causal layered analysis, chaos theory, cross-impact analysis, decision modelling, the Delphi method, environmental scanning, an expert panel, forecasting, a futures wheel, simulation, gaming methods, participatory methods (focus groups, interviews, mapping techniques, narrative analysis, role-playing), a prediction market, road mapping, scenarios, text mining, trend impact analysis, visioning and others.

The focus of this chapter is placed on participatory methods, which combine scenario building and gaming opportunities to enable the application of future thinking for policymaking, which is used by practitioners when working within a local government context. The focus is on participation, as expert forward looking failed to include diverse opinions. Therefore, stakeholder engagement became a standard in long-term perspectives (Gudowsky & Peissl, 2016). According to the same authors, including laypeople into forward-looking science, technology and innovation (STI) governance is underexplored but is crucial to co-creating valuable knowledge together with other stakeholders and experts (ibid.).

3.2. Scenario-based foresight methods

Scenarios may be developed by different sets of methods at diverse workshops by expert groups or may derive from Delphi or other survey results, etc. (UNDIP, 2004). Practically any forecasting or foresight approach can be a motive for a scenario-generating exercise. Scenario planning is a well-known and often used technique for thinking about the future. Building scenarios helps in identifying future opportunities and possibilities and, at the same time, provides assurance when acting with uncertainty (Jackson, 2013). Scenario-planning questions previously made assumptions about the future and created future alternatives, which could be used by decision-makers in determining their responses. They can be used to (ibid.) explore uncertainties and test limits, rank alternative future scenarios, identify emerging risks and opportunities, improve future assumptions, derive new visions and strategy development, carry out risk assessments of projects and organizations or to rehearse the future.

According to Lehoux et al. (2020), RRI and participatory foresight practitioners should formulate scenario-based methods in order to use experts and nonexperts in analysing the benefits of the past, reconsidering the present and in forming future scenarios and possibilities. This is done to inform anticipatory governance (ibid.). Boenink (2013) considers scenarios of the future important for considering and studying new and emerging science and technologies. Similarly, Urueña (2019) finds the creation of future scenarios a valued methodological tool for shaping the anticipatory governance of emerging technologies.

3.3. Gaming methods

Gaming methods in foresight are also very popular and useful, especially when the goal is to include people in community planning activities to gain insight into a problem, deal with future challenges or different upcoming or imaginary changes. In this way, gaming practitioners can generate new ideas, test behaviours, encourage the learning process and create a good atmosphere for productive discussions between different stakeholders.

Looking retrospectively, through history, the first games that were invented were war games (dating back to the 19th century), followed by serious games in the 1970s, as determined by Abt (1970). Their application is noted mostly in the social sciences, at the same time noting greater engagement of participants in physical games vs online games, with a new trend of future-oriented games having been identified (Bontaux et al., 2020).

Games are considered a powerful method for exploring possible ways of acting ahead of time as well as different solutions and measures. This is impossible to perform under the direct pressure of reality. Circumstances created in future games create a safe space to think because there is no "urgency" and participants have creative freedom (Bontaux et al., 2020). In the case of games, uncertainty, noted previously as the backbone of chance and the future, offers excitement, which participants/players need, but is also their main feature.

3.4. The Scenario Exploration System (SES)

The Scenario Exploration System is a foresight gaming system developed by the Joint Research Centre (JRC) of the European Commission. The objective of SES is to facilitate the application of future predictions in the area of public policymaking. SES is designed to engage different stakeholders in systematic long-term thinking and to explore alternative futures for particular issues on a variety of topics (in less than three hours). The four characteristics of the tool are versatility, a wide range of potential users, the ability to interact with a wide variety of participants and circumstances and adaptability (Bontaux, 2020).

This gaming system includes advantages of both scenario-based methods and gaming-based methods as it is a combination of both. In SES, four participants in the roles of scenario explorers establish their long-term objectives. They are allocated resources (represented by tokens) and they interact with other scenario explorers. The scenario master subjects them to foreseen and unforeseen events to which scenario explorers need to react. The public voice then judges the actions of the scenario explorers.

There are different Scenario Exploration System versions and adaptations that have been developed so far:

- Circular ocean: the goal was to find solutions for fishing nets and rope waste in northern Europe; SES managed to create a constructive conversation among the involved stakeholders (fishermen, port commanders, SMEs and fisheries agencies).
- Food safety: conversations were opened about policy work on food safety and food innovation after 15 years.
- Dragon Star: discussions between European and Chinese stakeholders involved in development and innovation activities (Research & Innovation) were initiated in order to create a long-term development strategy.

- Mobility is a serious game: representatives of the local and central government, business sector and NGOs are to meet in an educational environment and discuss different mobility scenarios, for example, on the topic of autonomous vehicle implementation.
- Climate KIC: the topic is carbon-free cities where contrasting scenarios are given to participants; for example, a market-driven vs a policy-driven scenario according to the local vision of the city of Bologna and Frankfurt.
- EU-InnovatE: participants interact with the radical social, political and economic changes that should take place by 2050; four scenarios for four opposing sustainable lifestyles are possible with a role of a citizen innovator and the "post-truth" public voice.
- Application of nanotechnology: an opportunity to talk about research directions with different interesting parties in different scenarios.
- Migration to the EU: an opportunity to talk about different scenarios with different interested parties from pro-immigration to anti-immigration populists.

As previously described, SES can be adapted to different policy contexts, and, for each, it offers a collaborative and experimental space that can be used for innovative policymaking.

4. DISCUSSION

Future studies, as "an empirical and scientifically based approach to understanding the future" (Lombardo, 2008, p. 109), seek to capture, understand and analyse possible future events, innovations and their implications in the form of opportunities and/or threats to humanity. This discipline is not novel, but its importance is especially recognised and emphasised in special conditions of global pandemics such as Covid-19.

This might be the right moment for the novel concept of anticipatory governance to be recognised along with its core component – foresight – especially taking into consideration the global agenda oriented towards sustainability (the 2030 Agenda for Sustainable Development) and the 17 Sustainable Development Goals (SDGs) that were adopted by all UN member states. Zovko (2013) finds exploration of the future to be a key part of sustainable development. This is particularly emphasised by the European Commission (EC) in the newly issued 2020 Strategic Foresight Report (SFR), which discusses resilience as the central theme of the mentioned report.

According to the Political Guidelines for the next European Commission (for 2019–2024), a strategic long-term direction would imply the transition towards a green, digital and fair Europe. The goal of the Commission is to put strategic foresight at the heart of EU policymaking with a goal to stimulate strategic thinking and form EU policies and initiatives (EC, 2020). The aforementioned first annual SFR defines how foresight will influence policies to strengthen the EU's resilience (its ability to withstand and cope with challenges) in four interconnected dimensions: social and economic, geopolitical, green and digital (ibid.). The report analyses the levels of the EU's resilience in the Covid-19 crisis. As seen in Figure 2.3, by strengthening capacities and mitigating vulnerabilities, Europe can improve its resilience, at the same time accelerating or decelerating relevant megatrends, which opens new opportunities in the above-mentioned four dimensions.

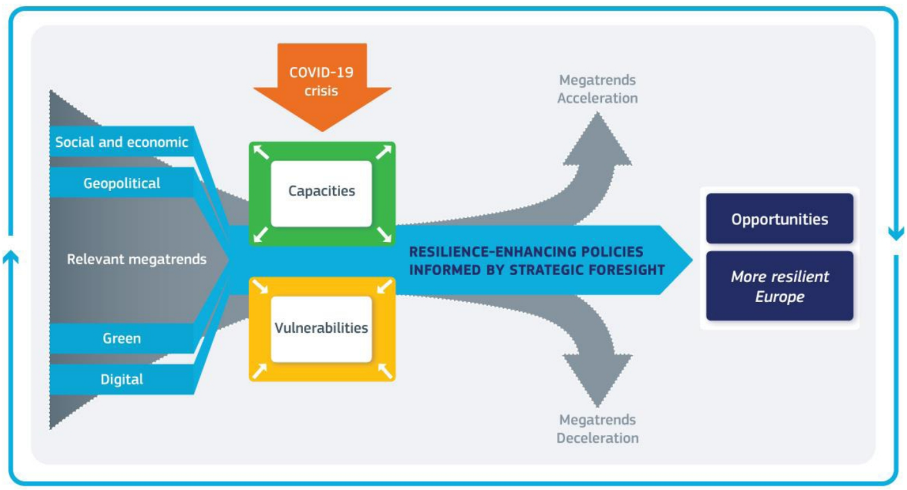

Figure 2.3: Link between strategic foresight and resilience (European Commission, 2020)

A forward-looking culture in policymaking in the EU is important in dealing with complex changes, and it is the basis for forward-looking policies supported by participatory foresight (ibid.).

Reviewing more globally, the most powerful economies (Israel, Sweden, Finland, Japan, Korea, Switzerland and the US) invest in future-studies research, with the aim of driving their society and economies towards sustainable development (Zovko, 2013). These countries have economic and human potential for conducting such research, and it is expected of them to become leaders in future development. It is interesting to note that these countries coped relatively well with the Covid-19 crisis in comparison to other countries. The academic community can help other countries to join the development of this scientific discipline so that future scenarios include local differences and preferences aimed at the ultimate goal of global progress and sustainability (ibid.).

4.1. Implications for urban development

The importance of anticipatory governance is noted in several studies that comprise the urban context. Most of them present just fragments or the initial emergence of AG, which shows that AG research is scarce, but it also shows the novelty of the AG concept, especially within the Smart City concept, in both scientific and practical contexts. One of the rare studies that incorporated AG in its research discusses Italy's governance during the Covid-19 pandemic. In their survey of 25 municipality mayors, Garavaglia et al. (2020) identified four key issues related to urban governance: (1) the importance of adaptive leadership and of anticipatory governance frameworks, which provide direction in emergency situations; (2) the importance of promoting institutional spaces for cooperation and collaboration with citizens as volunteers and of other stakeholders willing to contribute to public value co-creation; (3) the role of technology as an enabler and medium for sharing information and crowdsourcing resources; and (4) the importance of trusted platforms for knowledge sharing among the mayors and with other relevant organisational stakeholders.

In 2013, Wiek et al. defined a research agenda to support anticipatory governance of nanotechnologies in cities. The research programme “Nano and the City”, conducted in Phoenix, Arizona, combined AG principles (imagining, designing and influencing emerging technologies) with transformational sustainability science (giving a structured framework). At the end of the same project, Wiek et al. (2016) confirmed and called for sustainable and responsible innovation, which would incorporate AG with an aim of avoiding the shortcomings of conventional principles dominating emerging technologies.

Fragments of AG governance are recognised in studies done by Termini & Kalafatic (2021) and Derickson (2017). Termini & Kalafatic (2021) presented the results of a study done in Pennsylvania (USA), which explored the local government's work in adapting to climate change. Local officials did not recognise their work in water management as an adaptation to climate change. Although, they were reacting to water threats in two municipalities, and, in a single case, officials used a proactive approach with elements of anticipatory governance where they were building up the greater capacity of the water system to address future risks.

Derickson (2017) discusses two popular trends in urban governance – smart cities and resilient cities – which represent the governance of a city as a complex adaptive system that tends to anticipate and affect its future. She highlights the overly technocratic realm, which is solely focused on surviving possible future shocks and maintaining the status quo as opposed to new political and social urban formations. This "post-political" urban governance tends to use collected and aggregated data in predicting and anticipating futures, but it lacks a nontechnical side and citizen collaboration, which are necessary for it to be called anticipatory governance.

Two studies found in the literature discuss the importance of foresight, without mentioning AG. The first one is presented in a case study of a participatory foresight project that included citizens, experts and stakeholders in planning the future of aging in a city. The results show that urban governance needs to bear in mind both technological and human factors when considering innovation (Gudovski et al., 2017). The second one, by Wolfram (2018), highlights the importance of foresight in sustainability studies using the example of three South Korean cities. The concept was applied in the assessment of the transformative capacity of the three cities. The results point to defects in local policies in the cities as they followed national- and regional-level policies without contextualization, which is essential for reconfiguring social, technological and ecological systems at the local level.

4.2. Future actions and research

Searching the Croatian Scientific Bibliography (CROSBI) and Scopus database, research papers on the topic of anticipatory governance in Croatia have not been found, which proves to be an under-researched topic on all public administration levels.

Meanwhile, few studies containing foresight topics have been researched by Croatian authors (e.g. Zovko (2013) and Dabić in Gibson et al. (2018)). There is a study by Nyuur et al. (2015) covering the corporate sector, which is focused on the foresight capacities of small- and medium-sized companies in Croatia. Foresight studies at local, regional or central government levels have not been identified, which points to a large gap in the literature that should be investigated. Such results may point to scarce or no existing foresight included in the policies. To fill this gap further, investigation is needed primarily in implementing AG and foresight practices in the public sector and, especially, in highlighting the role of citizens and other stakeholders in cities.

Insufficient research from the public administration perspective has been noted in the above findings and has been highlighted as a research gap. Thus, solutions can be developed by intensifying academic and public sector cooperation, which will lead to more foresight implementation studies.

The mentioned gaps in the literature can be addressed by the following research propositions:

Proposition 1: Conducting (gaming) scenario-building studies within higher education institutions (HEI) and public institutions while working on tackling different future problems in different areas. By incorporating foresight tools, it is possible to raise awareness among public officials and show the importance and benefits of including anticipatory governance in urban governance, making it a part of strategies and, later, of policies and legislation. The needs of citizens and other stakeholders should be included as well.

Proposition 2: Measuring the impact of pilot foresight studies and final solutions in the form of public policies is very important. For that purpose, there is a need to develop and test impact indicators to measure AG benefits.

5. CONCLUSION

Anticipatory governance is required at every scale, from communal to global (Fuerth, 2009). It should be designed to employ foresight, which would result in governments that are able to foresee and adapt to future changes.

In the process of establishing AG, city governments should establish well-resourced systems and structures in partnership with citizens, which would allow continuous citizen involvement (Ramos, 2017) in the form of different participatory foresight methods. This chapter explains the main principles of AG and foresight while explaining three different participatory foresight methods that can assist local governments (cities) in launching foresight activities in an attempt to gather knowledge, which will later be used in managing the city. Having the tools (the three different SES games, including city greening, future mobility and eco-innovation) and the knowledge to use them, the author proposes conducting the SES game with graduate students during the Smart City Management course at the Faculty of Economics, Business and Tourism at the University of Split as a first step in promoting participatory foresight – which is needed for urban development – in the Croatian context.

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MODELLING BUSINESS PROCESSES AND CUSTOMER JOURNEYS IN SMART CITIES

3

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ABSTRACT

Over the years, business process management (BPM) has become an established management philosophy with a recognisable set of rules and principles for managing project development from its initial phase to completion, including urban development studies. Although its significance in project management is not questionable, a more conventional modelling approach, which includes business process management in urban development studies, often excludes citizens' needs and focuses more on internal initiatives. Considering current perspectives on urban development, local governments position the quality of life for their cities' residents as one of the top priorities. Accordingly, a Business Process Management–Customer Experience Management (BPM–CXM) approach is created in order to facilitate parallel modelling that consists of both internal and external modelling perspectives, taking citizens' experiences into consideration. For this purpose, the ARIS tool and ARIS Value Engineering were selected in order to enable BPM–CXM operationalisation. The approach presented in this chapter provides local governments with guidelines for redesigning current services and helping cities transition into smart development and growth.

Keywords: business process management (BPM), customer experience management (CXM), urban development, ARIS

1. INTRODUCTION

During the past years, many authors have recognised that internal, business-process initiatives are not aligned with external, customers' needs. Within the local government perspective, customers are mostly identified as citizens (and businesses). The objective and biggest challenge for the urban development of local governments is to provide efficient and cost-effective services to citizens and businesses (City of Zagreb, 2018). They are under immense pressure to conduct reforms and transition into smart cities.

Even though citizens were supposed to be the focus of any local-government-related improvement initiative, quite frequently, this is not the case. In the context of business and IT transformations that also encompass transitioning to smart city services, local governments, just like any other organization, are focused primarily on their own internal organization, which mainly implies conducting initiatives such as process, cost or time reduction through the optimisation of processes and organisational units.

This chapter defines critical concepts such as Business Process Management (BPM) – which includes identification, discovery, analysis, redesign, implementation and control – as well as Customer Experience Management (CXM), which, in the context of local governments and smart cities, includes an analysis of the experiential world of the citizen, designing brand experience, structuring the citizen interface, and continuous innovation (Schmitt, 2003; Dumas et al., 2018). While these two concepts remain at a distance in their traditional form, today, more than ever, it becomes relevant to study their touchpoints and reveal opportunities for making current services of the city "smart" enough to cope with the latest technological trends recognised globally.

For several decades, business process management has been around as one of the key approaches to optimising the performance of organizations (Dumas et al., 2018). At the same time, customer experience management has been widely adopted in order to have a positive effect on the analysis and the optimisation of the customer experience (Schmitt, 2003). BPM enables capturing, analysing and redesigning internal processes in order to transition to an intelligent or smart city. Establishing and maintaining the repository of internal processes was recognised as one of the first steps in creating smart cities (Vidovic, 2015).

According to Jeet (2017), BPM helps build smarter cities by enabling:
- enhanced e-Governance;
- breaking the silos;
- real-time processing;
- rapid adaptations to change.

One example of the application of BPM methods and tools, among others within the context of citizen enablement, is the City of Zagreb, where multiple projects were completed in the course of the last decade. It was also recognised as the best practice within the domain of organisational development (City of Zagreb, 2018). Nevertheless, this example can be related to the "open process innovation" concept, which is identified as an involvement of citizens (and businesses accordingly) within business process management initiatives (Niehaves & Malsch, 2009).

2. CONVERGENT MODELLING OF BUSINESS PROCESSES AND CUSTOMER JOURNEYS IN SMART CITIES

While current approaches mostly consider modelling of organisational processes from an internal perspective, new approaches are emerging, such as the one that combines business process management and customer experience management (BPM-CXM). By converging the two concepts, both internal and external (customers', users', citizens') perspectives are taken into account from the outset (Pavlic & Cukusic, 2019; Pavlic, 2021). Other than modelling and analysing internal processes, this approach elaborates on the parallel modelling and the analysis of customer journeys, with a specific focus on the analysis of the touchpoints with customers (citizens). Besides the mentioned convergence approach, there are also a number of other authors who recognised the importance of including customers' perspectives within internal transformation projects (Neubauer, 2009; Botha & Rensburg, 2010; Becker et al., 2011; Gersch, Hewing & Schöler, 2011; Johnston & Kong, 2011; Botha, Kruger & de Vries, 2012; Norton & Pine II, 2013; Bergh, Thijs & Viaene, 2014; Schmiedel, Vom Brocke & Recker, 2014; Trkman et al., 2015; Gloppen, Lindquister & Daae, 2016; Bernardo, Galvina & de Pádua, 2017; Frank et al., 2020).

Without a clear connection between the internal processes of the local government and the external journeys of the citizens, it is not clear which internal process optimisation leads to the improvement of which journey and vice versa. Design, modelling, analysis and testing of local governments' internal processes should be performed in convergence with the design, modelling, analysis and testing of citizens' journeys (and overall experiences) (Davis, 2011). That way, the prerequisites for setting up smart services would be met by providing the as-is transparency and a polygon for the to-be redesign within four crucial segments:

- Process
- Organization
- Technology
- Citizen-experience

2.1. The citizen's perspective within process management initiatives

Even though local governments and organizations in general frequently mention customers (citizens) as an integral success factor of projects for internal process reorganization, traditional approaches to business process management are primarily oriented towards the modelling and analysis of internal processes (Niehaves & Plattfaut, 2010; Temkin, 2010; Davis, 2011; Mendling et al., 2018; Helmy et al., 2020). However, an external perspective, which considers citizens and their journeys, is becoming more and more relevant (Rosemann, 2014; Gloppen, Lindquister & Daae, 2016). Some authors have recognised this synergy with the external perspective as the future of business process management (Richardson, 2016).

Many authors have emphasised the importance of customer-oriented process design (Rajala & Savolainen, 1996; Bolton, 2004; Alt & Puschmann, 2005; Heckl & Moormann, 2007; Brocke, Uebernickel & Brenner, 2010; Kohlbacher & Weitlaner, 2011; Margaria et al., 2012; Esfahani, Rahman & Zakaria, 2013). This is especially relevant within the strategic, early phases of process management and customer experience management initiatives. It is crucial to have an understanding of the external processes related to citizens and their needs in order to be able to set up and prioritize internal, organisational improvement initiatives. This is especially relevant in the context of transitioning from "traditional" to "smart" cities.

Modelling and analysing the perspectives of external citizens in convergence with the organisation of internal business processes can be recognised as a significant challenge, not only in respect to methodologies or operationalized approaches, but also the technological tools to support this.

2.2. A process management perspective within the citizen's experience

In order to improve the orientation of cities towards their citizens and enable smart city implementation, coordinated changes of internal business processes, as well as IT systems – which take citizens' expectations into account – are necessary. For the citizens' experiences to be improved, it is necessary to develop goals, identify key internal processes and key performance indicators, and associate the requirements of citizens with a city's internal processes. Based on this, priorities for future initiatives in the domains of business process management and customer experience management should be set.

Improvements to relevant internal processes in the context of optimizing the individual touchpoints as well as the entire citizen journey are made possible by better understanding citizens' experiences (Osman & Ghiran, 2019). Feedback from citizens in regard to their needs can play a crucial role in customer-oriented smart services.

An analysis of customers' needs should be the key prerequisite for any process-improvement initiative (Chen, Daugherty & Landry, 2009). Process improvements should be measured in the context of the evaluation of customer satisfaction (Lee et al., 2010). By monitoring the performance of internal processes and external experiences, priorities for optimizing those processes that have a significant impact on customer experience can be established (Ruland, 2016). That way, the root causes for increasing or decreasing customer satisfaction could be explained by the way in which internal processes are defined or are performing (vom Brocke & Rosemann, 2010).

3. THE BPM-CXM CONVERGENCE THEORETICAL MODEL

Process design and business process management were recognised as one of the main factors of achieving customer satisfaction (Scheer et al., 2005; Kumar et al., 2008). Customer experience management can be perceived through individual phases and activities of the business process management lifecycle (Ruland, 2016). According to this, in order to enable the optimisation of customer experience and customer journeys, modelling should be incorporated into business process management systems (Osman & Ghiran, 2019). This is very relevant in the context of smart cities, where redesigning current processes and organisational units is necessary for using technological advantages and serving citizens in a more efficient way.

A high-level concept of the BPM-CXM convergence model structured around the BPM lifecycle is presented in Figure 3.1. The BPM-CXM convergence model should be used as the main starting point for discussions on the processes and citizen-experience analyses necessary for transitioning to smart cities as it is structured in a way that would facilitate the integrated analysis of customer experience and internal, business processes. This model proposes that customer experience is designed and analysed by using customer journey mapping, which is used as an input for the strategic identification of processes for initiating process redesign (BPM) initiatives (Flint et al., 2005; Chen, Daugherty & Landry, 2009; Lee et al., 2010; Davis, 2011; Moormann & Palvolgyi, 2013; Vanwersch et al., 2015). The approach reflects the way in which customer experience can be perceived and analysed through the whole process management lifecycle (Ruland, 2016). It supports putting emphasis on the analysis of touchpoints between internal processes and customers, while using proven best practices from both business process as well as customer experience management.

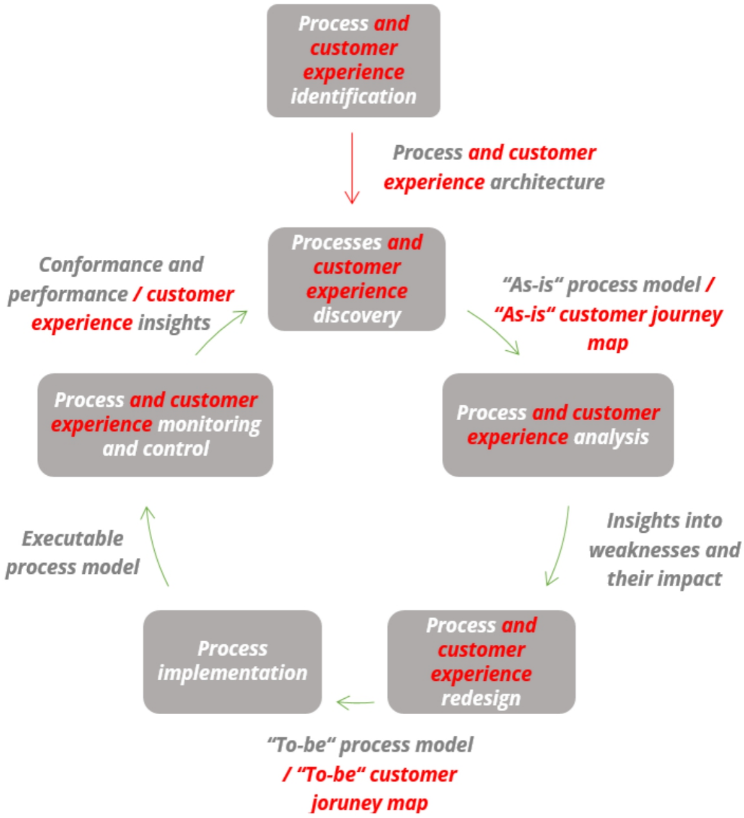

Figure 3.1: The BPM-CXM convergence model (Pavlic & Cukusic, 2019; Pavlic, 2021) (based on Dumas et al., 2018)

Other than identifying internal processes, the BPM-CXM convergent approach proposes identifying the processes related to customers, who are external to the organisation (Ruland, 2016). This is a prerequisite for a joint analysis in future methodological steps. Compared to traditional process and experience management methods, the convergent approach imposes a number of adjustments, which are briefly outlined below (Pavlic, 2021).

Organizations should have an insight into how satisfied their customers are with provided services as well as how well the internal processes are performing (Flint et al., 2005). Redesign priorities, in the context of introducing smart services, should be set so that initiatives address those internal processes which have the greatest impact on the customer and are not performing well at the time (Gustafsson & Johnson, 2006; Kreuzer, Röglinger & Rupprecht, 2020). Improving those processes should yield the biggest return on investment when looking at the effects on increasing customer satisfaction while keeping the internal processes optimized.

When the processes are designed, links between the internal processes and customers should be established (Kaplan & Norton, 1996; Klose, Knackstedt & Becker, 2005; Ruland, 2016). Links can be represented in a visual form by using "touchpoints" (Botha & Rensburg, 2010). Touchpoints should provide more detailed information on the customer's experience for each segment of the journey and direct the organisation towards improving those processes that generate the worst experience for the customers (Meyer & Schwager, 2007). The convergent BPM-CXM approach ensures that links or touchpoints are established between the organisation and customer. It is also important to point out that touchpoint analysis should be placed in an end-to-end context by analysing customers' journeys in their entirety, beginning before the interaction with the organisation and ending after it (Voorhees et al., 2017). The above-mentioned visual representation of touchpoints and journeys, besides establishing their connections with internal processes, is useful for not only aligning internal processes with the needs of the customers but also for delivering better services (Lee & Karahasanović, 2013).

In order to be able to determine if the internal processes would really result in an amazing experience for customers, organizations should quantify the relative importance of each phase of the journey for the customer (Payne & Frow, 2005). This analysis should also provide an explanation as to why customer satisfaction is dropping during certain phases of the journey (vom Brocke & Rosemann, 2010).

The impact and performance of processes from the customer’s perspective can be analysed by monitoring the data acquired from customers (Botha & Rensburg, 2010). Certain performance measurements are controlled in order to evaluate if processes are performing at a desired level, and this also provides an indication of which processes should be improved (Ruland, 2016). Techniques that can be used in order to gather data and evaluate customer experience include focus groups, one-on-one interviews, phone and online surveys and others (Schmitt, 2010). Techniques for internal process analysis include the analysis of the weak points of the organisational unit or its processes, organisational and process simulations, static and dynamic analyses of financial and time costs for processes and organisational units, etc.

(Van Hee & Reijers, 2000). The mentioned techniques and evaluations should result in an initial improvement proposal (Dumas et al., 2018). Any interaction (touchpoint) between the customer and the organisation generates certain data, which can be stored and analysed (Bolton, 2004). This data can be collected manually but also automatically from existing IT systems. Based on the predefined metrics and indicators, information that should be used within the next iteration of the internal process and/or customer journey design is gathered.

When the processes and/or customer journeys are redesigned and improvement proposals are approved, change implementation can occur. It is important to keep in mind that the implemented changes will have an effect not only on the internal organisation but also on the customer's journey. This is especially relevant in the context of the mentioned touchpoints between the organisation and the customer. Only when organizations redesign and implement their own internal processes in a way that fully supports the needs of their customers can strategic competitive advantages be achieved (Meyer & Schwager, 2007; Botha & Rensburg, 2010).

4. THE BPM-CXM OPERATIONALISED MODEL

In order to make the proposed theoretical model feasible in practice, models, objects and attributes were adjusted and/or developed within the market-leading business process management system – ARIS. ARIS and ARIS Value Engineering (AVE) were selected because of their wide usage within the EMEA region (Kapulin, Russkikh & Moor, 2019).

A set of models and objects are formulated within the BPM-CXM convergence model in the following way (Pavlic & Cukusic, 2019):

1. Process and customer experience identification: High-level processes and customer experience environments are identified by defining internal processes and external customer experience landscapes within the entry model.

2. Process and customer experience discovery: Current (as-is) processes and customer journeys are modelled. Touchpoints are established and act as a "bridge" between the internal (business process) and external (customer

journey) models.

3. Process and customer experience analysis: Internal processes and customer experiences are analysed, with an emphasis on links between or indications of an impact that individual internal processes have on forming a positive or negative customer experience.

4. Process and customer experience redesign: Based on the previous (analysis) phase, a redesign of the as-is business processes and customer journeys is conducted.

5. Process implementation: Redesigned processes are implemented within the organization, which can include changes in procedural, organisational or technological segments. These all have an impact on the customer's journey.

6. Process and customer experience monitoring and control: Business process and customer experience key performance indicators are monitored on a continuous basis in order to be able to evaluate the impact and the results of the implemented changes.

As elaborated by Pavlic and Cukusic (2019), the relevant models created using ARIS tools in order to enable BPM-CXM operationalization are as follows:

The Entry-Level Model: Compared to the traditional entry model elements proposed by AVE methodology (Scheer, 2000), this new model contains an individual quadrant for the customer experience landscape. Everything, from the entry level perspective to both internal processes and external customer experiences, is of equal importance.

Figure 3.2: The BPM-CXM entry model (Pavlic & Cukusic, 2019; Pavlic, 2021)

Customer Journey Landscape: This model encompasses a more detailed overview of the customer's perspective; it visualises customer lifecycle stage(s) alongside the underlying customer journeys. An overall customer experience attribute is calculated and monitored across the lifecycle stage as well as journey level. Objects within the model are represented in specific colours to indicate different customer experience levels.

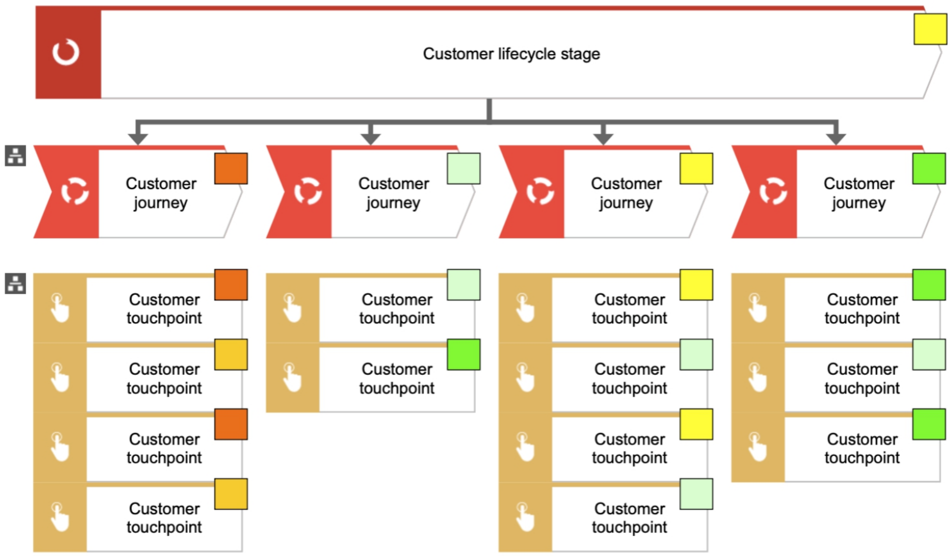

Figure 3.3: The BPM-CXM customer lifecycle stage model

Customer Journey Map: This model visualises an entire end-to-end customer journey, with the underlying journey steps before, during and after an interaction with an organization. It contains different objects relevant to the customer's journey: customer journey steps, touchpoints, channels, information carriers (inputs/outputs), risks, key performance indicators, improvement initiatives, functional ownership (organisational units or positions) and internal process functions.

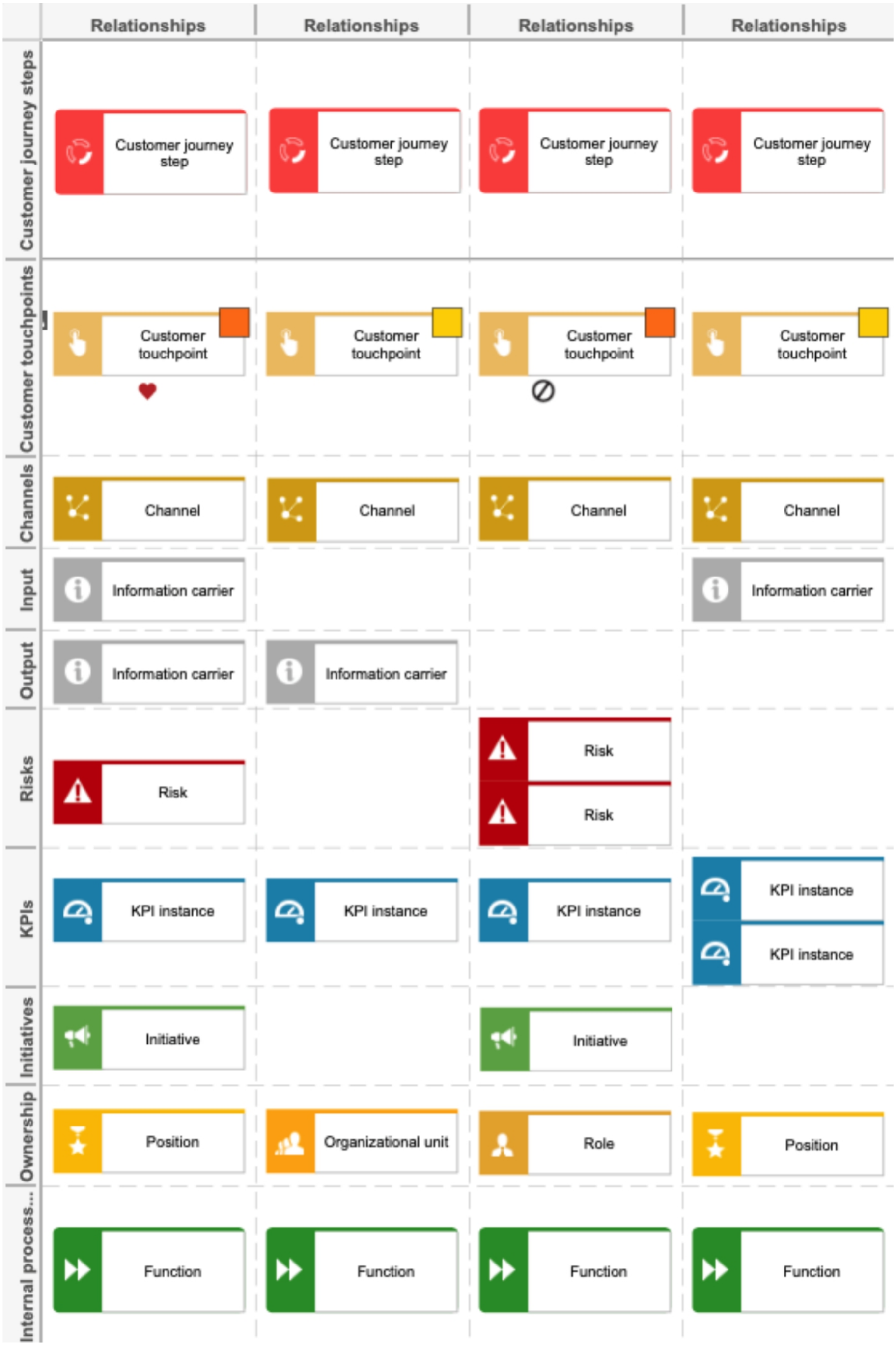

Figure 3.4: A BPM-CXM customer journey map (Pavlic & Cukusic, 2019; Pavlic, 2021)

Within the model, Overall customer experience indication is represented on an end-to-end basis as an attribute of the model. It is calculated by taking into the account the importance of each touchpoint of the journey for the customer and the customer's feelings. The data can be produced as a part of research, based on existing KPIs, or taken from existing IT systems and reused. Each touchpoint can optionally be a pain point, moment of truth and/or best practice.

Customer Touchpoint Allocation Diagram: This model is used for further detailing and analysing all the aspects of a customer touchpoint. Similar to the customer journey map (albeit now on an individual touchpoint level), the objects that the model contains are customer journey steps, internal process functions, positions (which represent the ownership of the touchpoint from an organisation's internal perspective), channels, risks, information carriers (inputs/outputs), key performance indicators and improvement initiatives. Each of these elements can be further described by using standard or customised attributes.

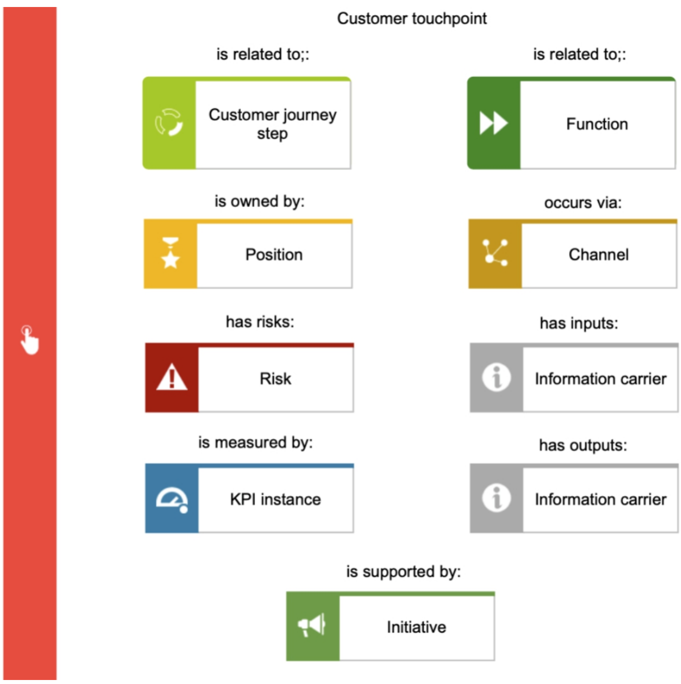

Figure 3.5: A BPM-CXM customer touchpoint allocation diagram (Pavlic & Cukusic, 2019; Pavlic, 2021)

Value-added Chain Diagram: This model shows a high-level process perspective. One important contribution of the BPM-CXM approach is that this model includes an indication of the overall impact of the customer experience generated by each individual process, which is calculated as an average of the customer experience of all the associated touchpoints of a particular process. It also provides an overview of the underlying touchpoints (with customer experience indication for each touchpoint) for each segment of the end-to-end process. Based on this, indications are provided on which internal processes should be optimised to improve the customer's experience.

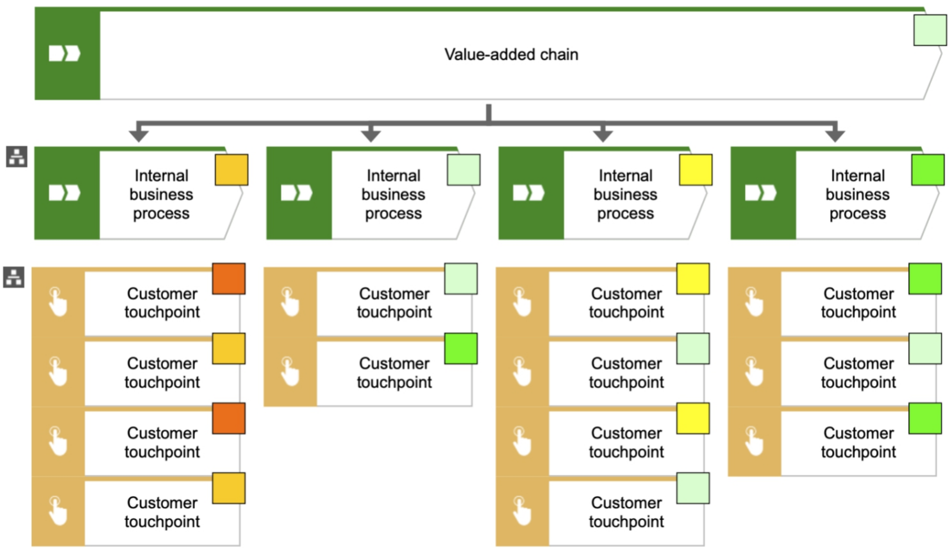

Figure 3.6: A BPM-CXM value-added chain diagram (with touchpoint representation) (Pavlic & Cukusic, 2019; Pavlic, 2021)

Event-Driven Process Chain: This model shows internal processes and their manual or automated activities at a granular level. In addition to the internal process steps and the associated inputs/outputs, organisational units, IT systems and risks, this model also contains touchpoints with customers. Touchpoints form a "bridge" between a customer and the organisation and are signified by a colour indication of the overall customer experience.

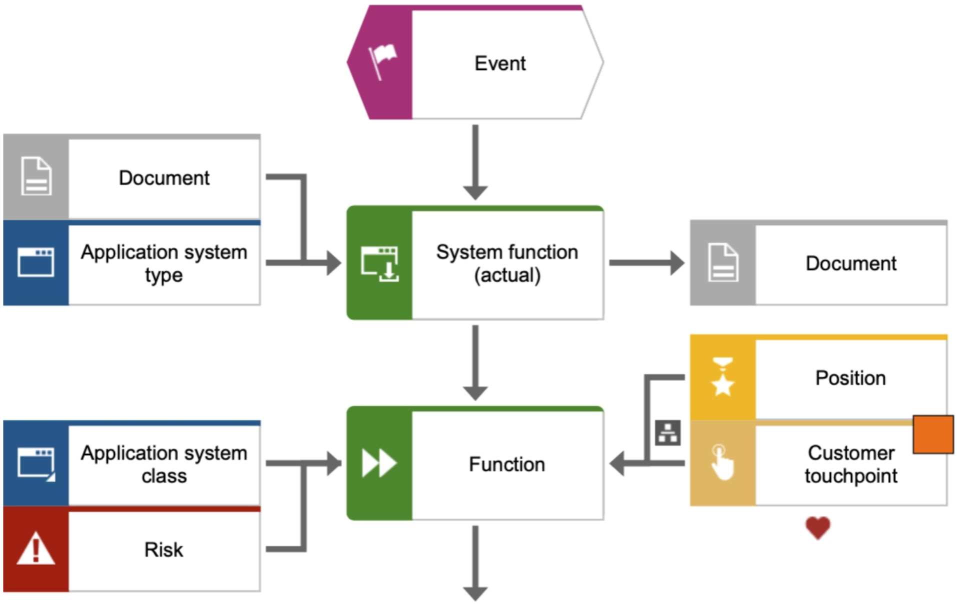

Figure 3.7: The BPM-CXM process model (with touchpoint representation) (Pavlic & Cukusic, 2019; Pavlic, 2021)

5. CONCLUSION

The BPM-CXM convergent approach establishes a synergy between the BPM and CXM strategic approaches. Considering that a process is as good as its weakest point, it is important to continuously improve end-to-end processes. While doing so, it is crucial to take into account not only the internal but also the external perspective or the needs of the customers (in the case of local governments – citizens), who are external to the organization, as well as the touchpoints connecting these two perspectives. In order to truly become citizen-oriented, local governments should fully understand the needs as well as processes from the perspective of citizens and design their internal processes accordingly. This should be a prerequisite for designing and introducing any smart-city-related services. As such, it should enable local governments to redesign current services and transition to a smart mode of operating within the four crucial segments: processes, organisation, technology and citizen-experience.

According to the gap recognised by Rosenbaum et al. (2017), the BPM-CXM approach enables the detection and analysis of touchpoints between the internal organisation and the customer as well as directing value generated by the organisation towards the customer. The approach recognises the customer journey as one of the processes that organisations should manage and continuously align with other processes. As a methodological approach to the analysis and evaluation of the impact that business processes have on transforming the customer journey and vice versa, it is useful as it provides valuable information to be considered alongside unavoidable transformation of the organisation and IT landscape. By using the proposed approach, a solid baseline architecture for understanding the needs of citizens as well as connecting them with internal processes would be established. Communication and general interaction between process management and customer experience departments would then no longer be kept separate. Better alignment of the internal process design and citizens' needs would be enabled. Internal employee satisfaction within the organization, as well as that of customers, should be improved by making their experience seamless through smart-city-enabled services.

In addition, by using the proposed approach, fulfilment of customers' needs is evaluated within the context of internal processes management. This enables added value for the customers, more positive customer experiences, better communication and transparency and better alignment of key performance indicators between departments. Based on this, the BPM-CXM approach can eliminate a lot of issues within the traditional approaches that are related to smart city transformations. It should align internal and external project goals, which should also lead to higher project success rates. It should also improve the organisational performance and customer experience in general. Compared to traditional approaches, it should result in internal process improvements parallel to increasing customer satisfaction. Therefore, it is evident that it is no longer possible to transform the internal processes of an organisation without taking into account its interactions with customers. Even though BPM and CXM were not very well-connected domains in the past, benefits of the convergent approach are significant, not only within the mentioned domains but for the entire organisation as well. Only when the initiatives for smart city services are aligned with the needs of the customer can transformation potential be fully used.

Challenges with implementing the BPM-CXM approach also exist. While citizen involvement can be a meaningful instrument, considering the nature of their goals, which can be misaligned with the organisational strategy, it might not primarily contribute to process optimisation in economic terms (Niehaves & Malsch, 2009). Furthermore, it is always a challenge to change existing organisational structures for whatever reason. The approach requires openness of employees towards change, which is sometimes the most significant challenge within an organisation. It is relatively complex and requires strong support from the management of the organisation. It also requires good cooperation of all stakeholders during implementation. This is relevant for the procedural, organisational and technological aspect. Stakeholders should also have a clear understanding of the goals and benefits of the approach in order to minimise their eventual resistance to change, which could have negative implications for the overall smart city implementation journey.

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DEVELOPING A CONCEPTUAL MODEL FOR SUSTAINABLE TRANSPORT INFRASTRUCTURE PLANNING: A SYSTEMS THINKING APPROACH AND PRELIMINARY DYNAMIC MODELLING

4

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ABSTRACT

Transport infrastructure plays a key role in sustainable urban development and its economic, social, and environmental impact. With the rapid urbanisation that has occurred in the 21st century and sustainability becoming an inevitable topic, transport infrastructure has become a vital strategic component of urban development policies. Many studies highlight transport infrastructure as a fundamental component of sustainable development since most economic and social activities are related to the efficiency of the transport sector. Consequently, this chapter investigates the application of conceptual modelling using systems thinking and dynamic modelling in sustainable development and urban mobility through infrastructure performance estimation and an analysis of available infrastructure capacities. System dynamics contribute to a deeper understanding of transport systems and relations between system variables by managing proper simulation mechanisms and utilising systems thinking. The contributions from different scientific disciplines help identify multidisciplinary connections within sustainable development and transportation to define relationships between supply and demand for transport services. The result of this chapter is the creation of a causal loop diagram (CLD) for planning transport infrastructure, using the VenSim software, presented through a case study of the East Coast area of the city of Split, Croatia. The research approach leaves enough space for further experimental analysis using system dynamics, within the same case study, in order to assist in specifying optional strategies and solutions in rearranging transport investment (for example, extending infrastructure capacities for road transport – including investments in public transport infrastructure aimed at reducing road congestion – and supporting sustainable alternatives).

Keywords: sustainable development, infrastructure capacity, transport systems, urban mobility, systems thinking and modelling

1. INTRODUCTION

In 1987, the Report of the World Commission for Environment and Development (WCED, 1987) described sustainable development as development that meets the needs of the present generation without compromising the ability of the upcoming generations to meet their own needs. Despite its short history, sustainable development is considered to be a multidisciplinary concept that influences many economic, social and environmental prospects (Shao, Li & Tang, 2011). Goldman and Gorham (2006) suggest that sustainable development is an effective and reliable concept because of its intuitive policy and its ability to adapt flexible frameworks alongside economic and environmental challenges and social aspirations. Although the main pillars of sustainable development are economic, environmental and social forms of capital (Elliot, 2013, p. 20; Harris, 2000; Giddings, Hopwood & O'Brien, 2002) and their interactions (Gonzalez-Feliu, 2018, p. 45), some authors extend the concept by adding ethical, technological, political and other forms of capital (Pawlowski, 2009; Lankauskiene & Tvaronaviciene, 2012).

According to Cheba and Saniuk (2016), evolving economic, environmental and social requirements are the primary challenges for sustainable urban logistics as an integral part of urban development. Banister and Lichfield (1995, p. 1) add that urban attractiveness, which is often treated as an important issue for efficient urban mobility and transportation, largely depends on relative accessibility, which relies on the quality of transport infrastructure. Similarly, different sources presented in Cheba and Saniuk (2016) emphasise the correlation between urban accessibility and the level of infrastructure development as well as its economic and social potential. Therefore, transport infrastructure investments are commonly seen as a critical catalyst in the process of urban development (Lee et al., 2020), enabling higher urban mobility performance and transportation of people, goods, services, and information from one location to another (Rodrigue, Comtois & Slack, 2013, p. 1).

With the undeniable influence on a city's sustainable development (Shen et al., 2018) and urban population growth (United Nations, 2019), expectations for a more effective, supportive and sustainable transport system are evolving (Shen et al., 2018; Ngossaha et al., 2018). Accordingly, transport infrastructure has become an integral part of urban development strategies (Badada Badassa, Sun & Qiao, 2020), since no economic or social sector is independent of the transport system's performance (Morchadze & Rusadze, 2018).

Considering the significance of urban mobility in sustainable development (Cheba & Saniuk, 2016; Skorobogatova & Kuzmina-Merlino, 2017) and the importance of transportation and environmental planning for urban growth (Waddel, 2002), many authors found simulation modelling to be appropriate in managing various aspects of the field (Hosseinali, Alesheikh & Nourian, 2013; Kekez, Jadrić & Ćukušić, 2021). Simulation modelling is used frequently as a reliable tool for urban mobility management (Ćukušić, Jadrić & Mijač, 2019), making system complexity, types of problems and decision maker requirements the main factors in choosing a suitable modelling approach (Currie et al., 2020). Since transportation-systems research is a complex field, with multiple system variables, relations and loops, systems thinking and system dynamics are considered appropriate approaches to describe system behaviour, characteristics and variable connections (Suryani et al., 2022; Wang, Lu & Peng, 2008). As an introduction to system dynamics modelling, systems thinking is a causal approach that describes the relationships between system variables using causal loop diagrams as a supportive building mechanism for further model development (Suryani et al., 2022).

Based on the above premises, this chapter applies systems thinking and preliminary dynamic modelling to create a conceptual basis for further simulations of various transport infrastructure strategies, to identify the impact of different scenarios on urban mobility and utilise systems thinking in a complex environment such as a transport system. Systems thinking often relies on subjective intuition for evaluating the complex structures that emerge from the initial observation of the real-world system (Forrester, 1994), supporting the ability to understand how real-world systems operate (Sterman, 2002). Furthermore, Sterman (2002) adds that a holistic view of real-world systems facilitates faster and more effective learning and helps in making better long-term decisions. Theoretical and practical similarities and differences between systems thinking and system dynamics are presented in Richmond (1994), but it is necessary to understand that systems thinking is not quite the same as system dynamics, although they overlap in many areas.

In order to contribute a better perspective of both terms, within this chapter, systems thinking is related to conceptual modelling of causal loop diagrams, whereas system dynamics involves building and simulating conceptual models using machine language, utilising an appropriate simulation modelling tool. Consequently, the study evaluates suggested approaches as being vital for reliable system build-up, taking both methodological advantages and disadvantages into consideration. This indicates that the study is considerably inspired by the described methodologies and their usage in the fields of sustainable transportation and urban development. Finally, this chapter primarily aims at systems thinking and problem modelling rather than suggesting definitive transport solutions to reform the performance of its activities, indicating the presence of potential opportunities for further research within the case study area.

The remainder of this chapter is organised as follows: A literature review on urban sustainability, transport infrastructure planning and corresponding methodologies is elaborated on in section two. Section three dives deeper into the research mechanisms of systems thinking and modelling. Section four introduces a case study of East Coast Split. Section five presents the results in conceptual system modelling of causal loop diagrams and dynamic preliminary modelling. Finally, section six draws a conclusion to the study with future directions for dynamic submodelling simulations to analye the effectiveness of different infrastructure strategies for urban sustainability, traffic efficiency and mobility.

2. LITERATURE REVIEW

2.1. Transport infrastructure and urban development

Population growth and increased migration to urban areas, in correlation with transport congestion and decreased efficiency of urban mobility, are driving demand for many transport infrastructure projects (Nguyen, Cook & Ireland, 2017). Transport infrastructure regulates mobility, determines transportation landscape architecture, influences trade flows and affects various social assets of urban residence (Short & Koop, 2005). As discussed in Saidi et al. (2020), the growing impact of transportation on regional development pushes governments to increase infrastructure investments in order to achieve long-term sustainability of transport systems and stimulate economic growth. Results correspond with sustainable policies for developing effective urban logistics while taking care of congestion reduction and negative environmental consequences. Moreover, investments in urban transport infrastructure are often at the heart of efforts to trigger economic growth, as insufficient quality of proper infrastructure is considered a constraint for numerous countries (Alder, 2015).

Although the mentioned studies demonstrate that investments in transport infrastructure have a significant impact on urban economic development, some authors argue that transport infrastructure in itself is not sufficient to achieve favourable sustainable outcomes. More specifically, Crescenzi and Rodriguez-Pose (2012) investigated the relationship between transport infrastructure investments and regional growth in the European Union (EU-15) from 1990 to 2004 and concluded that there is no significant evidence that European transport investment policies largely contribute to regional development. Furthermore, Elburz, Nijkamp, and Pels (2017) discovered a disparity in the outcomes of various infrastructure investments for specific countries and regions with different levels of development (their research included three categories: the US, Europe and "Others"). The authors conclude that differences in research methodology, techniques, data types and measurements, research periods, observed areas and their characteristics all play a prominent role in obtaining positive or negative study outcomes, thereby being able to influence final observations and conclusions. In addition, it is possible to call upon the fact that most regional transport infrastructure projects require large land areas and long-term investments, and, often due to its scope and schedules, the project cycle stretches over years or even decades, making it harder to evaluate.

Interestingly enough, results shown in Hong, Chu, Wang (2011) correlate with the mentioned discoveries in Elburz, Nijkamp and Pels (2017), where it was found that infrastructure investments contribute differently within particular regions of China, especially those including land transport infrastructure. The lower the starting infrastructure quality is, the higher the impact on economic development. Xueliang (2013) complements the conclusions on transport infrastructure investments using China as a research subject, noting that infrastructure investments, including investments in transport infrastructure, should focus on the spatial efficiency in specific regional areas. Therefore, many researchers have complemented these conclusions using mathematical and simulation modelling techniques in their studies in order to evaluate and predict different land-use implications (Shen et al., 2009; Zheng et al., 2012; Geng, Zheng & Fu, 2017). This may include spatial changes at a macro scale (such as planning new urban transport systems, e.g. the creation of new urban centres) or a micro scale (local infrastructure projects, e.g. transport infrastructure rearrangement, such as the East Coast Split case study) (Lee et al., 2020).

2.2. Sustainable urban logistics and the Smart City

As urban logistics has a considerable influence on quality of life, a variety of sustainable transportation topics within the Smart City concept are becoming increasingly popular among researchers (Koglin, 2017; Benevolo, Dameri & D'Auria, 2016). Sustainable urban development and the Smart City concept represent growth paradigms that emerged as a result of the drive of cities to be more responsive to citizen requirements, elevate the quality of life within the city and enhance competitiveness in an increasingly globalised environment (Angelidou et al., 2017). Additionally, making a city "smart" is an innovative way of reducing the problems caused by urban population growth and fast-paced urbanisation (Chourabi et al., 2012).

Rapid population growth and urban migrations are causing many technical and infrastructure problems, lowering the city's functionality and decreasing citizens' quality of life (Gil-Garcia, Pardo & Nam, 2015). However, cities can only be smart and sustainable if there are adequate technological solutions that can integrate and synthesise data collected through multiple sources regarding the movements of people and goods, as well as information on the physical and societal shape of the city (Batty et al., 2012). Because of the popularity of the concept and its elements, different interpretations may appear in various research areas (Ninčević, Ćukušić & Jadrić, 2020), including urban planning and transport system development.

Hall et al. (2000) shared the following vision of a smart city and its infrastructure: „A city that monitors and integrates conditions of all of its critical infrastructure, including roads, bridges, tunnels, railways, airports, seaports, etc., can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens." Likewise, Harrison et al. (2010) combine different infrastructure elements, including transport infrastructure, to leverage the city's intelligence.

Additionally, besides urban infrastructure and comparable to the earlier statement by Banister and Lichfield (1995), Giffinger et al. (2007) emphasise the importance of urban accessibility for city development as well as the availability of ICT and sustainable transport systems, all under the framework of smart cities and smart mobility. Alongside infrastructure-oriented topics, smart mobility also investigates a variety of issues specific to traffic management strategies, vehicle tracking as well as security in transport (Ismagilova et al., 2019) and encourages sustainable development by optimising transport services while taking into consideration its economic, social and environmental challenges (Zawieska & Pieriegud, 2018).

2.3. Systems thinking and dynamic modelling for transport infrastructure planning

Compared to traditional qualitative and quantitative methods for transport infrastructure analysis and transport systems in general, systems thinking helps conceptualise the relations between system variables, whereas system dynamics quantifies them through the building of dynamic differential equations using simulation tools (Xue et al., 2020). As a research methodology, the concept of system dynamics developed from a system theory in the business management field during the late 1950s under Jay Forrester at the Massachusetts Institute of Technology (Wolstenholme, 1982), and, over the years, expanded its research areas at an exponential rate (Forrester, 1994) to include urban studies as well as transport systems and infrastructure (Shepherd, 2014).

Some of the previously cited studies in this section successfully adopt and present a system dynamics approach in order to simulate and validate the consequences of different land-use strategies, including land transportation, but additionally revealed an absence of transport infrastructure planning in the process. Simulation planning with system dynamics enables “what-if” scenario experiments, which is a valuable complementary technique to infrastructure project management because of its ability to incorporate the more subjective factors within causal loop diagrams and “communicate” the relations between system variables of infrastructure projects (Rodrigues & Bowers, 1996; Richardson & Otto, 2008). Additionally, system dynamics is considered to be a convenient tool for risk management in infrastructure project development due to a lack of systematic approaches and instruments for identifying and expressing the interactions among economic, societal and environmental challenges in project development (Boateng et al., 2012). Therefore, many authors identified research potential between transport infrastructure planning, land-use strategies, systems thinking and dynamics modelling and, consequently, provided additional research literature to support sustainable development and infrastructure project management.

Haghshenas, Vaziri, and Gholamialam (2014) developed a dynamic transportation model using systems thinking and dynamics in order to analyse different sustainable transportation policies. System analysis and model development included sustainable transportation indicators, trip generation modules and both private and public transport infrastructure capacities. Jiang, Li and Xu (2010) used a system dynamics approach to estimate the impacts of different transport infrastructure investments on tourism development and revenue from tourism activities in certain regions of China. Nguyen, Cook, and Ireland (2017) combined system dynamics with cost-benefit analysis in order to evaluate the economic and social impacts of transport infrastructure investments and estimate possible outcomes of different scenarios. Similarly, Wang et al. (2018) estimated the influence of transport infrastructure investments on the regional economy and employment rate to help policymakers evaluate the possible outcomes of different strategies. The authors conclude that system dynamics modelling is an appropriate technique for transport infrastructure planning, and it can be effective in economic forecasting and analytics.

In order to achieve promising sustainability performance in transportation, Shen et al. (2018) implemented a dynamic model to investigate sustainable policies for transportation development and mobility performance in an urban area. The study included both transport demand and infrastructure supply to support day-to-day urban activities and development on a macro scale. In addition, some authors combined system dynamics and transportation planning for urban mobility improvement, including infrastructure capacity expansion and its influence on urban sustainability (Wang, Lu & Peng, 2008; Noto, 2017). More specifically, Wang, Lu, and Peng's (2008) simulation process included a subsystem modelling approach divided into seven related submodels of an urban transport system, focusing on vehicle policy and its effects on urban development.

Considering the demonstrated insights, it is possible to conclude that transport modelling deals with an increased number of system interactions simultaneously, making systems thinking inevitable in the process.

3. RESEARCH METHODOLOGY

This study combines the systems thinking and dynamics modelling approach into a mutual format, focusing primarily on conceptual modelling of a complex system in order to set a valuable basis for further infrastructure capacity analysis and performance estimation under particular sustainable and transportation challenges in the area. Thus, both methodologies are applied to model development since they are part of a system theory and are complementary to each other. At this stage, the research included a dynamic hypothesis elaboration, which requires the creation of a dynamic model that will, in further testing, be built on the conceptual foundation created through this research.

Within this framework, system dynamics is a methodology that applies different methods and tools to support systems thinking, facilitate modelling, analysis and learning about real-world problems, structures and processes (Forrester, 1961; Sterman, 2001; Goh & Love, 2012). Simulated models are "representative" or "substitute" structures of the real-world system they represent (Mäki, 2005), defined by a set of statements about a targeted system (Seidewitz, 2003). However, no matter the amount of detail in which a real-world system can be examined, it is impossible to identify all the system variables and their relationships (hidden loops), which affect system behaviour (Richardson, 1986).

Furthermore, it is not recommended to make an overly detailed system model because of its potential to underperform and the impracticalities of working with extensive models. Additionally, system modelling is not a time-definitive process but an indefinite one, since many system changes affect its structure evolution, causing it to grow over time, adding difficulties to analyses and providing new system insights to system analysts. Even if most of the variables are inactive, the remaining active system variables form a new system structure with different practices and rules. Therefore, a good model is a trade-off between realism and simplicity (Maria, 1997).

The process of systems modelling consists of two main procedures: causal loop modelling (systems thinking) and stock-flow modelling (system dynamics). This study focuses mainly on systems thinking. Forrester (2009) specifies that all system activities are closed-loop structures – a network of feedback loops where every action or change generates some return. These types of feedback present a fundamental step in designing a dynamic hypothesis using systems thinking. Furthermore, feedback loops can be positive – generating value increase of the primary system variable (called the "reinforcing loop"), negative – generating value decrease of the primary system variable (called the "balancing loop"), and time-delayed – a feedback with system delay on return. Time delays are modelled as a specific feedback channel due to their long-run response nature (Sterman, 2002), be it because of the time needed for the system to trade off primary intervention or the time needed to stabilise around its average values.

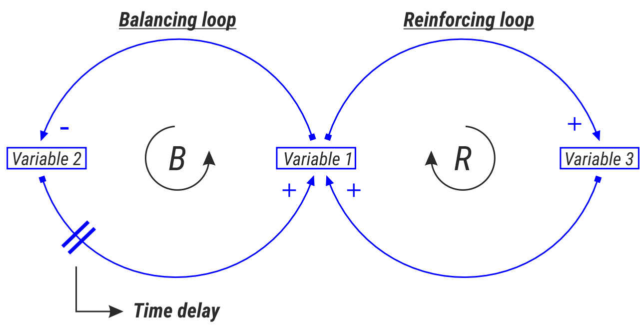

Figure 4.1: Causal loop diagram (Yu et al., 2014)

The stock-flow model is made up of three types of variables – stock, rate and auxiliary variables – and two types of flows – material and information flow. System variables, together with material and information flow, create the basic structure of a dynamic system (Shen et al., 2009). The ability to describe dynamic processes continuously with time delays and study cumulative system changes makes system dynamics a worthy approach for various sustainable development issues (Xue et al., 2020) as well as transportation-oriented topics (Coyle, 1996). Simply put, the stock is a resource accumulation changed over time (*t*) and by a rate determined in a flow. The way that flow operates is defined using an operational statement (syntactic rule) controlled by a current state of stock compared to a system's goals (Forrester, 2009).

In a given interval of system simulation, the flow controls the ongoing (i.e.

accumulated) state (i.e. value) of stock by changing its system behaviour (i.e. oscillations) from positive (increase) to negative (decrease) and vice versa (strictly positive or negative system accumulation), or system stabilisation around goal-seeking values (Sterman, 2000, pp. 107–133). Patterns of behaviour are accumulated in time on the stock and can be affected by different inflow rates, which can be hidden or shown in the final system model. Therefore, adding a time interval is essential for the dynamic nature of system dynamics models as differential equations calculate the rate of a system change continuously during the specified time interval (*t(0)–t(n)*). A mathematical relationship between stock and flow can be expressed using the equation:

$$S(t) = S(0) + \int_0^t [Fin\_flow(t) - Fout\_flow(t)]dt$$

where: (1) *S(t)* is accumulated stock value in time (t), (2) *S(0)* is the initial stock value and (3) *Fin_flow(t)* and *Fout_flow(t)* represent a differential flow in time (*t*). The remaining system (i.e. auxiliary) variables help calculate the flows or communicate the stages of the calculation process (Caponio et al., 2015).

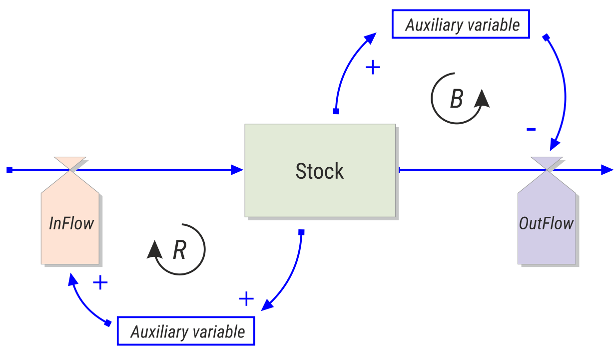

Figure 4.2: Causal loop diagram displaying stock and flow structure (Author's drawing based on Sterman, 2001; Yu et al., 2014)

4. CASE STUDY

According to local authorities' reviews (City of Split, 2005), the future development of a city largely relies on the quality of transport infrastructure and the ability to meet growing transport demand, especially that initiated in the tourist season, during the summer months. The logistics role of the city in local and regional transportation is determined by its geographic position and the fact that the city of Split is the largest regional centre on the eastern side of the Adriatic Sea coast (Tourist Board of the City of Split, 2017; City of Split, 2005). The East Coast area, which is located near the city centre and on the eastern side of the city riviera, plays a vital logistic function for the city and the local community. The mentioned location comprises different private and public transportation options whose transport infrastructure capacities are divided into three functional areas: (1) road infrastructure, (2) rail infrastructure and (3) port infrastructure.

Figure 4.3: The land transport infrastructure area of East Coast Split, Google Maps (author's work)

According to the urban master plan document (European Bank for Reconstruction and Development, 2020), land ownership and size is divided between (1) Port Authorities – 95,900 m[2], (2) Croatian Railways – 42,900 m[2], (3) the City of Split – 32,500 m[2], (4) private property – 21,000 m[2] and (5) the Republic of Croatia – 6,700 m[2]. These areas amount to approximately 199,000 square metres of land. For its transport purposes and functionality, this area is divided as follows: (1) road infrastructure – 32,500 m[2], (2) rail infrastructure – 42,900 m[2], (3) port infrastructure – 95,900 m[2], (4) remaining land infrastructure with an unspecified transport purpose – 27,700 m[2]. Due to seasonal traffic congestion, the idea behind the recently proposed transport guidelines is to reduce some types of transport (i.e. a strategic relocation to the area of Kopilica in Split), which would eventually result in numerous positive impacts on transportation and urban sustainability in general. Besides active transport activities on the East Coast area, access to the various modes of transport located on the land area during the summer months presents a significant issue. Additionally, public infrastructure capacities are insufficient for proper transport mobility performance of the local community (Institute for Development and International Relations, 2019). Currently, the observed transport system is off balance, since there are types of transport with low infrastructure resources and high transport demand (road infrastructure) while others have lower requirements and increased available infrastructure resources (rail infrastructure), causing them to be inefficient but due to low usage rates (European Bank for Reconstruction and Development, 2020).

5. SYSTEM STRUCTURE AND CAUSAL LOOP DEVELOPMENT

After determining the scope of the research methodology and setting up the theoretical basis required for understanding the system, the next step was to create a conceptual model starting with a system assumption relation. Urban transport mobility is displayed as a relationship between transport supply and demand, continuously observed in the experimental time interval *t(0)–t(n)*, where system stock (state) is the sum of an initial system state *t(0)* and accumulative state over time *Δt(0-n)*:

$$Urban\ transport\ mobility = \frac{Transport\ supply\ (t(0) +\ \Delta t(0-n))}{Transport\ demand\ (t(0)\ +\ \Delta t(0-n))}$$

In other words, the stock value at time unit *t(0)* is not an inclusive part of the *Δt(0-n)* expression but a starting value in the initial time unit of the continuous simulation flow. Methodologically, the reason for the given form (and not *t(1)*) lies in the characteristic of continuous simulations to describe the dynamics of real-world processes during the entire simulation process where there are no predetermined simulation time units (excluding the start and end of simulation process – *t(0)* and *t(n)*). Continuous simulations track the system's behaviour over the duration of the simulation run, while events in sequenced time intervals (e.g. *t(1), t(2)–t(n)*) are features of discrete-event simulations where the system state between particular events remains stable.

Transport supply represents the capacity of available transport infrastructure in the area within the time interval, while transport demand refers to the amount of the system's “population”, i.e. system entities in the transportation network that have identified transportation needs over the equivalent time interval. Therefore, it is possible to distinguish the two main principles of transport mobility: (1) effectiveness – the transport service is/is not realised, regardless of the assigned time interval or (2) efficiency – the service is/is not performed within a specified time interval, under specific conditions, optimised and cost-effective.

In addition, transport infrastructure planning requires the differentiation of two terms used in this study – infrastructure performance estimation and available infrastructure capacity. Infrastructure capacity is the highest obtainable practical value of a selected infrastructure resource in a particular time unit or time interval. Infrastructure performance estimation is a potentially achievable (sustainable) value (benefit) of added infrastructure investments. The added infrastructure investments may or may not exist to improve infrastructure capacity and reach the estimated infrastructure performance as each unit of infrastructure resource is restricted by its diverse conditions and the boundaries of the observed area (geographical, ecological, social, etc.). Infrastructure investments, the capacities of which have reached the highest achievable infrastructure performance, are often maintenance costs or similar expenses.

Additionally, the East Coast area has a large amount of other system variables (not solely transportation-oriented variables). Therefore, it is impractical to allocate all investments into one infrastructure resource in order to achieve the highest estimated infrastructure performance as this would imply the exclusion of all remaining transport infrastructure facilities, which are in the service of area mobility and other economic, environmental, and societal requirements of the area.

According to available data (Tourist Board of the City of Split, 2017), tourist arrivals are a dominant factor determining a demand for transport services during the summer months but are not the only factor. The population also consists of passengers and locals who utilise the available infrastructure resources for mobility services. Terminologically, a passenger who activates an available infrastructure resource can be a tourist or a local individual. According to the World Tourism Organisation (n.d.), a tourist is a visitor (domestic or foreign) if their visit includes an overnight stay or a one-day trip. Therefore, a tourist is a type of passenger, while tourism is a subset of travel as it refers to the individuals who move between geographical locations regardless of the purpose or duration. Furthermore, the system “population” entity does not have to be exclusively a person but can be a vehicle or other form of motorised and nonmotorised transportation. They perform differently and have different infrastructure requirements and mobility purposes. All together, they form a system population of the model expressed as follows:

$$System\_population = System\ \_population\ t(0) + \int_{t(0)}^{t} [System\_population\ (\Delta t)]dt$$

In theory, economic development influences transport demand and attracts more population migrations (Wang, Lu & Peng, 2008). The urban populations' migrations also impact tourist arrivals (Griffin & Dimanche, 2017), which causes an increase in demand for transport services, creating additional pressure on transport supply i.e. infrastructure capacity. If the local authorities (government) cannot respond to the transport demand requirements by supplying enough transport infrastructure resources, this could lower urban transport mobility and discourage additional economic activities. Considering that economic development positively correlates with population migrations in the long run (including vehicle-owning policies), and a decrease of urban mobility performance negatively affects economic growth, possible consequences could lead to a system's population loss over time.

Hypothetically speaking, a causal relation between urban mobility effectiveness and economic development is positive because the growth of one variable on average causes the increase of another and vice versa. However, an increase in transport demand also brings up some undesirable consequences, which have a negative causal relationship to economic development, such as ecological and social issues (see Figure 4.4). In other words, if population growth causes an increase in traffic demand, then, consequently, it negatively affects the congestion on land. Insufficient infrastructure capacity then contributes to the growth of gas emissions (air pollution) in transport, noise increase, etc. (Suryani et al., 2022).

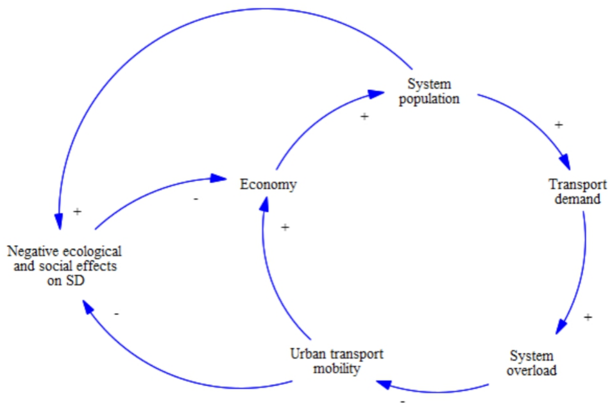

Figure 4.4: Introductory causal loop diagram of transport system relations (author's work)

Furthermore, because of the advantages and disadvantages of higher transport demand, the accumulated state of system stock affects the economy, illustrated as the gross domestic product (GDP) in the conceptual model (Figure 4.5), whose rates determine added transport infrastructure investments. The higher the GDP rates, the more added investments there will be (Wang et al., 2018). By default, added transport infrastructure investments enhance transport effectiveness and efficiency (i.e. decreasing time delays in the system, achieving more system entrances, reducing infrastructure occupation and mobility dropdown rates, etc.). Additionally, as urban mobility policies include a variety of sustainable development aspects (i.e. ecological challenges), added infrastructure investments should also stimulate investments in a public (sustainable) infrastructure and correspondingly reduce the possibility for unwanted outcomes due to higher transport demand. The rearrangement of private transport infrastructure and rethinking the implementation of public forms of transportation contribute significantly to pollution reduction and help reduce traffic congestion (Titos et al., 2015; Xue et al., 2020).

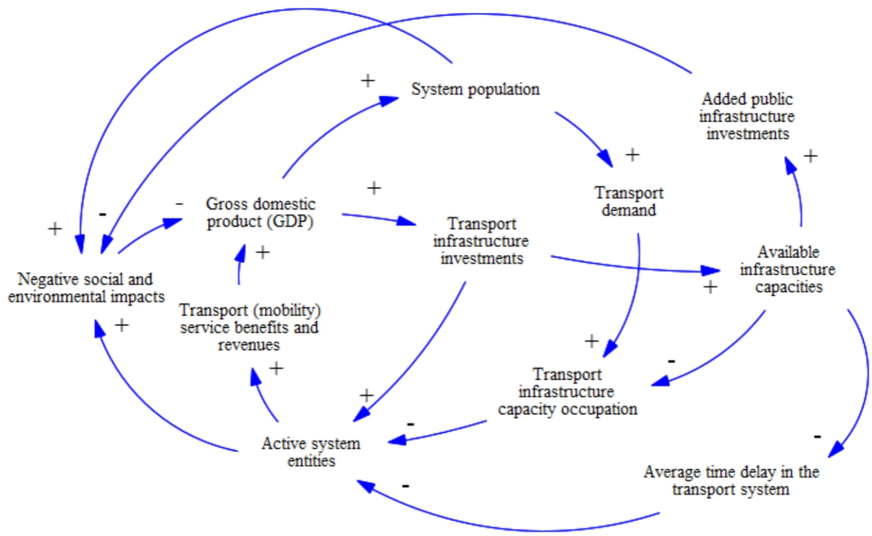

Figure 4.5: The first extension of a causal loop model of a transport system (author's work)

Figure 4.5 presents the first extension of a conceptual model. In short, the system population increases the transport demand, where one registered entity arrival can occupy one or more transport infrastructure resources (capacities). The higher transport demand gets, the more pressure is placed on infrastructure capacities, consequently lowering available infrastructure capacities over time. Upon infrastructure capacity occupation, a system individual (entity) generates (1) positive effects such as revenue from transport services within the area (returns are not necessarily financially oriented; they can include a variety of desirable short-term or long-term effects on the sustainable development achieved by economic and transport activities); and (2) negative effects such as increased gas emissions for motorised vehicles, waste generation, traffic noise, etc. The accumulated change in time impacts the GDP stock balance used as an economic state indicator to perform added infrastructure investments, prioritising sustainable alternatives in the transport system.

Furthermore, the GDP balance change also operates as an economic indicator for evaluating the tendency of vehicles policies in the transport system as well as other system variables in follow-ups, such as population migrations, tourist arrivals, etc. Therefore, both system population and infrastructure capacities are affected by the economic oscillation in a model, leaving local authorities and analysts to determine guidelines for managing urban mobility as a relationship between supply and demand for transport services, while also considering infrastructural boundaries of the area and urban sustainability goals.

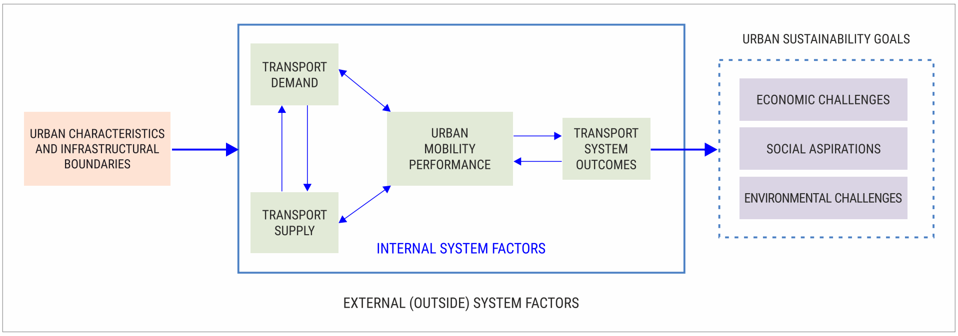

Figure 4.6: Transport system factors (author's drawing based on Haghshenas, Vaziri & Gholamialam, 2015; Haraldsson, 2004)

Shen et al. (2018) suggest it is more suitable to work with transport supply (infrastructure capacities) in operating transport performance by analysing the impacts of transport infrastructure investments and evaluating infrastructure capacities. In order to experiment with infrastructure capacities and estimate their potential, Nguyen, Cook, and Ireland (2017) defined transport congestion (i.e. system overload) in time units (*t*) as:

$$Transport\ congestion\ (t) = \frac{Active\ system\ entities\ (t)}{Transport\ infrastructure\ capacity\ (t)}$$

where (1) *Active system entities (t)* are the amount of actual transport demand (system population) in a time unit (*t*) and (2) *Transport infrastructure capacity (t)* represents available transport infrastructure capacities in an equivalent time unit (*t*). Bernardino and van der Hoofd (2013) extend the earlier equation by adding dynamic value and describing transport congestion as a relationship between aggregate transport (system) flow and average population (entity) speed:

$$s(Qa) = \frac{s(0)}{1 + \alpha(\frac{Q(a)}{C(b)})^{\beta}}$$

where (1) *s* is the average entity speed in the transport system, (2) *s(0)* is the average free-flow speed in the transport system, (3) *Q(a)* is the average traffic flow (entities/day), (4) *C(b)* is the aggregate infrastructure capacity parameter and (5) *α, β* are the model calibration parameters.

In order to estimate available transport infrastructure capacities, Ojha et al. (2018) formed a qualitative and quantitative model representation using road infrastructure capacities as a research topic. This model includes various road infrastructure factors, which directly affect available infrastructure capacities, such as (1) *Connectivity Issues (Tci)* – infrastructure capacity loss due to connectivity issues caused by external and internal system factors; (2) *Infrastructure Maintenance (Tim)* – short-term temporary infrastructure capacity loss due to ongoing maintenance; (3) *Traffic Jams (Tpz)* – temporary infrastructure capacity loss due to transport congestion (system overload) or traffic accidents; (4) *Infrastructure Construction (Tgp)* – permanent or temporary infrastructure capacity loss with potentially long-term duration due to infrastructure investments/projects or infrastructure conversion into other facilities; (5) *Infrastructure for Special and Emergency Causes and Transport Modes (Tpop)* – permanent infrastructure capacity loss due to the specific requirements or other transport mobility purposes that are not directly linked to traffic-related services.

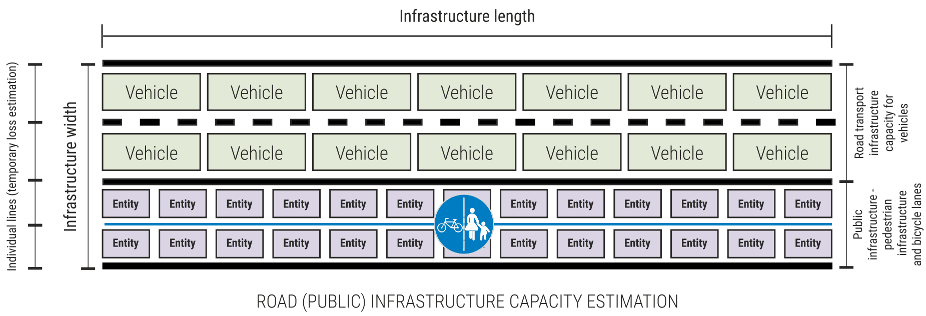

Figure 4.7: Road (public) infrastructure capacities estimation (author's drawing based on Ojha et al., 2018)

Another type of infrastructure loss includes “spatial” loss due to *security distance (Tsu)* estimation between entities or system boundaries, which equals the minimum estimated percentage needed for a secure distance between the system population in traffic.

The aggregate of the permanently lost, temporarily closed and securely distanced infrastructure represents total infrastructure capacity loss (*Tuk* = *Tci* + *Tim* + *Tpz* + *Tgp* + *Tpop* + *Tsu*).

Finally, the *available (net) infrastructure capacities* are equal to the “remainder” of the estimated total infrastructure capacity loss *(Tuk)* subtracted from the infrastructure capacity of the area:

Available (net) infrastructure capacities = *Transport infrastructure capacity – T(uk)*

where transport infrastructure capacity equals the total land area in a particular time unit or time interval and is determined by the spatial boundaries of the East Coast area.

Total infrastructure land area **(t)/[*t0*]<m2>** = Road infrastructure(t)/[*32500*]<m2> + Rail infrastructure(t)/[*42900*]< m2> + Port infrastructure(t)/[*95900*]< m2> + Remaining land infrastructure with unspecified transport purpose (t)/[*27700*]< m2>

Accordingly, Figure 4.8 depicts a causal loop diagram of described transport congestion (Nguyen, Cook & Ireland, 2017; Bernardino, van der Hoofd, 2013) and infrastructure capacity relations (Ojha et al., 2018) as a whole.

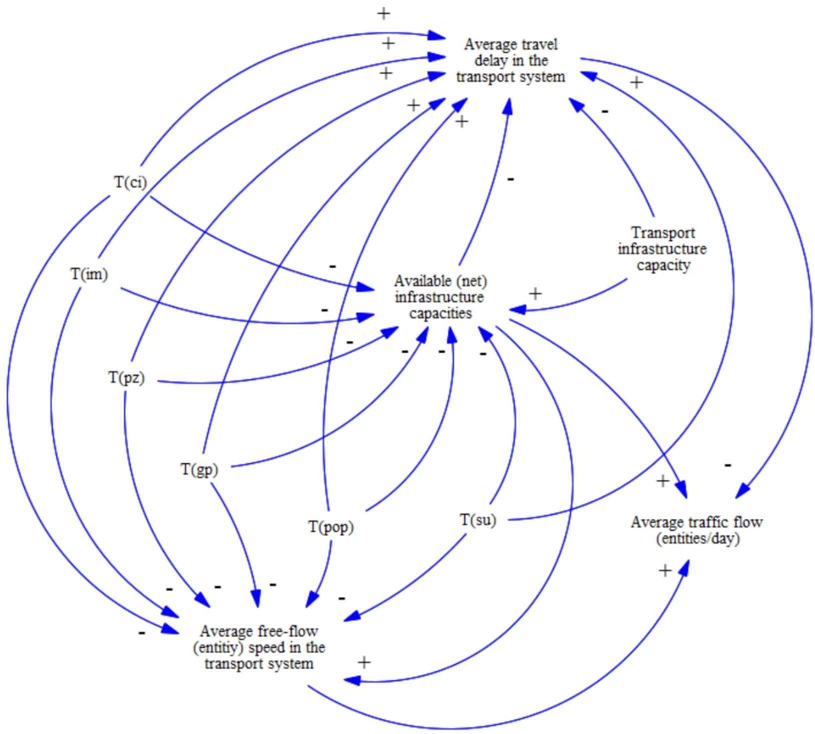

Figure 4.8: Causal loop diagram of available infrastructure capacities and transport congestion (author's drawing based on Bernardino & van der Hoofd, 2013; Ojha et al., 2018)

In short, the increase of available (net) infrastructure capacity will, on average, decrease the hold time in model per system unit and increase average system flow (entities per day) and average entity speed in the transport system and vice versa.

By analysing the available net capacity, two features can be recognised: (1) Permanent loss and security-conditioned infrastructure loss are singularly valued in the conceptual model; (2) Temporarily lost capacities are a part of ongoing maintenance and similar short-term activities. The consequences of temporarily lost capacities are often estimated in short-term intervals using parameters such as average entity speed in the transport system, average free flow in the transport system, or average traffic flow. These parameters are more practical for discrete event simulations and less for system dynamics but are equally valuable for system understanding via conceptual modelling using the systems thinking approach.

In addition, available (net) road infrastructure incorporates land area for public (sustainable) transport infrastructure. Public transport utilises the available road infrastructure without lowering transportation efficiency or effectiveness while decarbonising urban transport. Therefore, public infrastructure is integrated into road infrastructure capacities as a unique form of urban mobility that includes a variety of sustainable forms of transportation. In other words, both infrastructures help meet the demand for transport services but use different infrastructure content (e.g. public sustainable infrastructure includes pedestrian infrastructure, bicycle lanes, etc.). Along with the causal loop development, Figure 4.9 was made by synthesising the causal loop models shown through this section to provide a holistic view of all variable relations included in the system model development of the East Coast area.

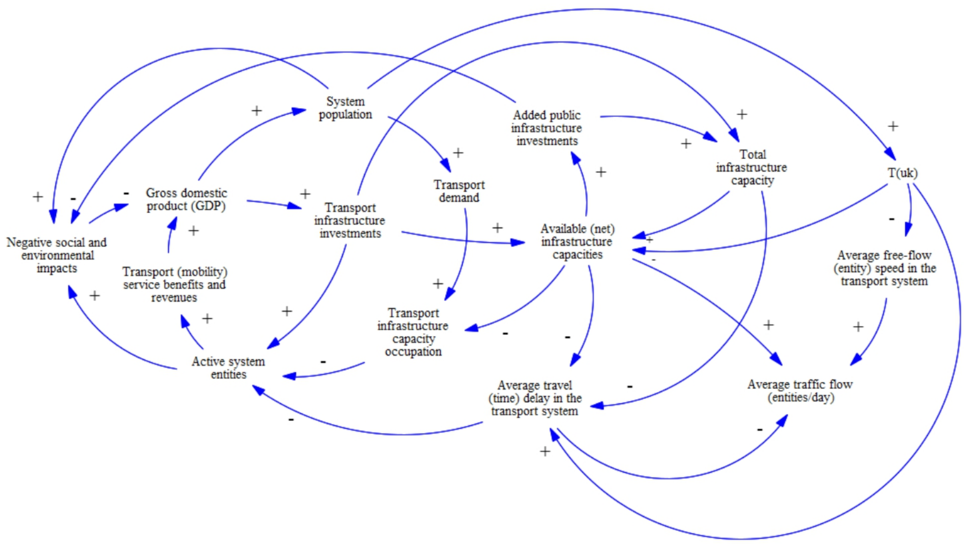

Figure 4.9: Definite causal loop diagram for transport infrastructure planning (author's work)

The final causal loop model represents the conceptual base – a systems thinking step required for dynamic stock-flow, quantitative modelling. Still, the suggested causal loop diagram (Figure 4.9) does not depict all the inner connections between system variables (which is called the "system complexity issue"). Additionally, some variables contain a higher number of inputs with the accumulated output (*e.g. T(uk)*), describe more than one system variable (e.g. infrastructure capacities), or contain different entities within one variable (e.g. system population). Furthermore, the outlined variables of a system model do not represent its boundaries, since the complexity of transport systems grows over time; systems tend to evolve over time under various internal and external influences.

6. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The objective of this study was to create a conceptual model using a systems thinking approach and dynamic modelling of an urban mobility performance of the observed area as a relation between transport demand and supply, focusing primarily on infrastructure capacities in operating transport performance. As capacity deficiency of the land transport system is a considerable factor influencing urban development (Yu et al., 2014; Wen & Bai, 2016), this chapter examines a variety of studies to enhance transport infrastructure planning using systems thinking as an introductory approach to the development of system dynamics models. The created causal loop model helps recognise the relationship between transport system variables by determining available infrastructure capacity and long-term mobility potential. Likewise, in order to be up to date on sustainable practices, environmental challenges are factored into the model in the form of the development of sustainable alternatives (public infrastructure), which are meant to respond to social and ecological issues. Therefore, public infrastructure is a critical infrastructural component of transport systems since it facilitates sustainability in urban development by encouraging transport solutions that positively affect social and environmental issues without compromising mobility performance. Although this study uses a specific research subject as modelling support, the presented approach can be generally applied to support development in other land areas with similar research issues.

Further research for the presented case study requires the creation of a system dynamics model based on the result of this study and preliminary dynamic model guidelines discussed throughout the chapter. Additionally, it is required to collect and examine all the available data about transport demand in order to test and validate dynamic scenario models for infrastructure performance estimates in the long term and find the best possible way to compromise potential data unavailability due to the system complexity of the area, especially in those areas that include an estimate of the proposed infrastructure projects of the land area.

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PART 2

Perception, intentions and attitudes towards smart city elements, concept challenges, use cases of digital technologies in smart cities, empirical analysis

ATTITUDE TOWARDS SMART CITY ELEMENTS: SELECTED TRENDS AND A COMPARATIVE STUDY OF DIFFERENT RESIDENTS

5

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ABSTRACT

Technological progress has determined the shift towards promoting economic growth and social improvement. Today, cities are eager to become "smarter" and aim to do so by embodying characteristics connected to the vision of sustainability. Nevertheless, smart cities are not only focused on developing or applying new solutions but also on learning and educating residents on how to build a sustainable environment. In order to investigate how smart city services are perceived among the general population in Slovenian and Croatian urban areas, a survey was performed using an online tool. The participants (N = 1390) expressed their attitudes using a Likert five-point scale, with one meaning they strongly disagree and five meaning they strongly agree. The results were sorted into eight categories: interest in technology, security in smart cities, privacy in smart cities, smart mobility, environmental issues with smart cities, waste pollution, noise pollution, and light pollution. Although there are some concerns regarding security and privacy issues, in general, both Slovenians and Croatians are open-minded toward smart city development as they believe it could improve their quality of life.

Keywords: smart city services, technological development, sustainability, quality of life

1. INTRODUCTION

The urban population has been rising by 65 million people a year, on average. This indicates the highest level of urbanisation in history, but, as it grows, environmental pressures intensify as well. The increasing population density in urban areas causes numerous environmental issues. The concerns about sustainability are constantly rising, which is another reason why a smart environment is highly relevant and should be further addressed. There are three major trends within smart environment practices: air quality monitoring, energy use optimisation and waste reduction. Smart solutions in these fields are extremely promising as their implementation is expected to result in 10–15% fewer greenhouse gas emissions and 30–130 fewer kilograms of solid waste per person per year (Woetzel et al., 2018).

When visualising a smart city, the image that appears is a city that can offer its citizens a high quality of life by using resources in a sustainable way, through the implementation of innovative technologies. The term "smart city" does not have a single and specific definition. Since its first introduction as a concept in Silicon Valley, it has been widely used and applied in different contexts, thus carrying different meanings (Lindskog, 2004). The general concept of a smart city revolves around the combination of studies in urbanism as well as information and communication technologies with some aspects of creativity and participation in society. It involves the reorganisation of the city structure and the improvement of the living conditions of its citizens. It usually requires the use of technological tools, such as the Internet of Things or Artificial Intelligence. However, it is also based on a collaboration between governments and different departments of society and involves changes to the contemplative side of society (Ruohomaa, Salminen & Kunttu, 2019).

In order to facilitate the transition to a smarter city, there are several factors that need to be changed before starting to implement improvements. The roles of each contributor should be specified in order to stimulate collaboration between all departments. Citizens should not only play the role of observer but rather take part in the process and actively participate by applying innovative thinking. Organisations should also transform their role from providers to partners that are willing to collaborate on the development of the city. Smart cities should not only be focused on the digitalisation of city services but also on supporting the process of transformation by involving society departments, governance and encouraging collaboration between city stakeholders (Vanolo, 2014).

2. CHARACTERISTICS OF SMART CITIES

There are different characteristics that a smart city can have, such as a smart economy, smart people, smart governance, smart mobility, a smart environment and smart living (Capdevila & Zarlenga, 2015). For each of these areas, the literature provides several possible definitions.

Smart economy primarily revolves around effectively allocating economic resources (Apostol, Balaceanu & Constantinescu, 2015) while dynamically adapting to current situations. The allocation of economic resources refers to a monitoring process that controls how wealth is created and distributed within the economy. The main idea behind a smart economy is to reduce modern social problems related to poverty: hunger, inequality of opportunity and others. A successfully implemented smart economy concept can help individuals choose how to earn and use their income, ultimately improving the individuals' quality of life while reducing unemployment levels within the society.

Definitions of smart people mainly focus on the inclusion of citizens in the development of the smart city itself. Smart cities are cities consisting of smart people who can positively influence the community through their creativity (Capdevila & Zarlenga, 2015). Additionally, smart cities should not only focus on developing the technologies used but rather educate their citizens on how to use these technologies (Lacinák & Ristvej, 2017). Nevertheless, even the most cutting-edge smart city would fail to achieve its purpose if smart citizens were missing.

Smart governance revolves around smart cities allowing for smart collaboration. For city governments, this affects both the institutions' governance and the institutions' policies. Smart governance can thus be defined as (Israilidis, Odusanya & Mazhar, 2021) the process of not only citizens but also other public, private and civic stakeholders being involved in the city's governance process. Smart governance builds on all these players collaborating and innovating together, creating an interconnected society (Haque, Bhushan & Dhiman, 2021). In a survey conducted by the EU commission, 63% of EU citizens would like to have a digital ID. This would allow them easy access to governmental procedures like tax filing or other public services. It would also allow EU citizens the opportunity to easily use public service providers in other countries.

Smart mobility is a rather straightforward term and addresses the increase in traffic in cities all around the world. Moreover, by reducing traffic, it can also have a positive effect on the environment, by reducing pollution. Smart mobility within smart cities therefore tackles concerns regarding travel time, energy efficiency and environmental issues. One clear-cut trend in smart mobility is the use of autonomous mobility. Although still in a very early development stage, autonomous vehicles seem to be a possible solution for the previously mentioned problems that smart mobility is trying to address (Manfreda, Ljubi & Groznik, 2021). Another trend in the area of smart mobility is car sharing. In 2015, the number of worldwide users was at seven million, but this is expected to increase dramatically to up to 36 million users in 2025.

The area of smart environments deals with improving the sustainability aspects of a city. The use of technology is supposed to create a sustainable living environment whilst utilizing natural and economic resources more efficiently (Haque et al., 2021). The sustainability approach allows for the development of a sustainable healthcare system and inspires a greener lifestyle. One trend in this area is the implementation of so-called "smart ports". By changing the infrastructure of industrial ports, it is possible to not only improve the economic efficiencies, but it is also possible to reduce the negative effects on the environment. The Smart Port initiative in Rotterdam, Netherlands, aims to become a “renewable energy hub” and a “recycling hub”.

Smart living tackles all aspects dealing with the quality of life of each citizen. The term “quality of life” can be seen in various definitions. Improving quality of life is such a broad term; it allows for many interpretations. Generally, smart cities use ICTs to improve the quality of life of its citizens (Capdevila & Zarlenga, 2015). Important factors contributing to quality of life are education, health and safety as well as social cohesion and tourist attractivity (Giffinger et al., 2007).

3. DEVELOPMENTAL STAGES OF SMART CITIES

According to their level of "smartness", cities are divided into five or six phases or generations (six counting cities without any of the characteristics of smart cities). A city moves up the rankings depending on the way it adopts new technologies and developments. The phases can be divided as follows (Khan et al., 2022):

- Smart City 1.0: Development is driven by large technology vendors, i.e. companies with many resources and influence, such as Google, IBM and CISCO. The largest criticism of the first phase of smart cities is their imposition of technology and the great impact that technology companies have.

- Smart City 2.0: The second phase of the smart city is also driven by technological progress. However, this one, unlike the first, is aimed precisely at solving specific problems of cities, such as pollution, cleaning, health and transport. Problems are addressed and solved in cooperation with residents, and their involvement, because of poor organisational structures, is still at a low level.

- Smart City 3.0: The third phase of a smart city is driven by the expectations of residents or users. A smart city thus represents a whole connected ecosystem, which brings together technologies, solutions, actors (management, strategists, solution providers) and users (residents) of the city, including IoT (the Internet of Things), 5G connectivity, transport, smart mobility, energy and public services, health and public safety, Artificial Intelligence and data analytics.

- Smart City 4.0: With the advent of Industry 4.0 concepts, the positive effects of smart cities are expected to finally exceed their costs. Smart City 4.0 brings together all the best properties of previous phases (technological disruption from phase 1.0, individualisation from phase 2.0 and inclusion from phase 3.0) but adds two key success factors: an integrated approach and problem solving by integrating different solutions. An integrated approach aims to integrate new technologies with old ones and also includes the possibility of integrating solutions that have yet to be developed. Municipality management is well aware of the opportunities and limitations of new technologies and the overall impact that smart city technologies can have on their community. Self-awareness is still widespread in terms of influencing certain residents of the community, since not everyone feels the same positive effects.

- Smart City 5.0: The last phase of smart cities is dominated by Artificial Intelligence, namely cooperation between people and AI systems. Its approach allows for a consensus between different services and residents. Past and current events are constantly identified and analysed, which are then translated into plans, implementations and supervisions.

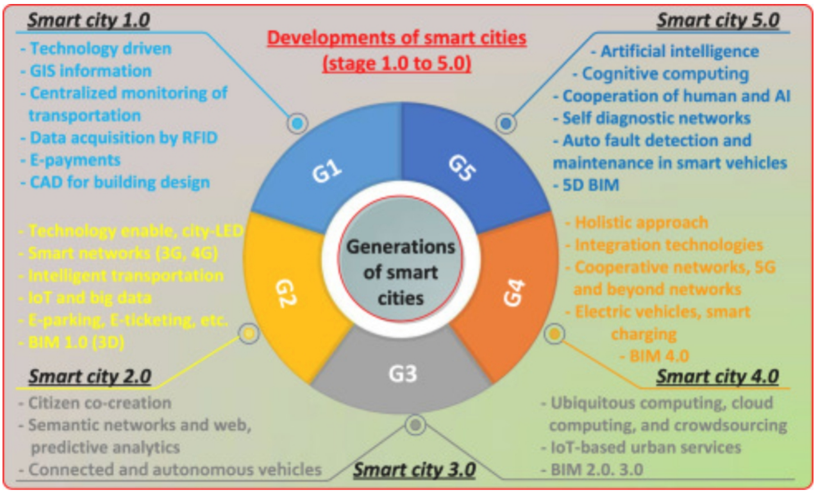

Figure 5.1: Stages of smart city development (Khan et al., 2022)

4. CHALLENGES RELATED TO SMART CITIES

It becomes clear that a lot of challenges revolve around data security issues. In 2015, Deloitte reported that the technology used within smart cities requires a massive amount of data. Consequently, the question of how to deal with this data appropriately is raised. In a study conducted by Manfreda et al. (Manfreda et al., 2021), data security issues appeared to be very high. These potential privacy issues range from citizens giving away confidential information unwillingly, users being monitored during various activities or even users not being able to access the smart services at all (Haque et al., 2021). As most devices used for the implementation of smart solutions currently rely on third-party services, there is a big chance of hackers getting into the system, spreading malware or feeding the system with wrong data. In the case of a large cyberattack on a smart city, a well-interconnected city might lose control over a lot of processes within its whole infrastructure (Haque et al., 2021).

After all, big data offers cities the opportunity to gain valuable insights from the vast amount of data collected through a variety of sources, and the Internet of Things allows the integration of sensors in a real environment using high-network services. The combination of the Internet of Things and big data is an unexplored field of research that has brought new and exciting challenges to achieving the goal of future smart cities. These new challenges focus primarily on business and technology issues, which enable cities to actualise the vision, principles and requirements of smart city applications by realising the key features of a smart environment (Hashem et al., 2016).

More generally, smart cities rely on its citizens actually using the provided solutions. The adoption of new technologies is highly dependable on the potential users' beliefs in the solution actually being useful (Manfreda et al., 2021). Thus, this raises an important question: whether implemented solutions are really useful to the user or whether the solution solely feeds corporate interests (Calzada & Cobo, 2015). This aspect cannot be highlighted enough, since the best solution is worthless if users are not using it. Therefore, user-friendliness appears to be one of the most important aspects of creating a smart city solution. Additionally, one has to think about citizens who are not able to use technological devices or smart solutions in general. In their report from 2015, Deloitte describes this aspect as the potential for widening the gap between citizens, since some of them might be left behind because of a lack of internet access or "digital savviness".

5. SELECTED TRENDS AND ISSUES

5.1. Waste reduction solutions

Before the industrialisation and globalisation processes started, solid waste did not pose a significant threat as the rate of its disposal per capita was incomparable to contemporary levels. However, consequently, it has become an extensive problem due to the continuous growth of the population and the corresponding amount of generated waste. In particular, the amount of food waste worldwide is roughly equivalent to 1.3 billion tons, which is enough to feed three billion people. Comparing it to the 690 million people who suffer from malnutrition nowadays, we can clearly see that the situation can be significantly improved by the implementation of corresponding smart solutions.

Some cities have managed to reduce the volume of solid waste generated by implementing effective recycling programmes, but these programs have certain limitations. This is why existing waste management infrastructures for waste collection, segregation, transportation and final disposal can be improved through the integration of smart city technologies (such as the Internet of Things, Artificial Intelligence, cloud computing and intelligent transportation systems) with the existing waste management system and infrastructure for waste collection, segregation, transportation, treatment and final disposal (Shukla & Hait, 2022).

As a first solution, digital tracking and payment for waste disposal can potentially enable a city to charge citizens for the exact amount and type of rubbish they throw away. This practice is widely considered nowadays, and detailed plans for its implementation are already established in some UK cities. The pay-as-you-throw system helps reduce the amount of unrecycled municipal solid waste generated per capita by 10–20%. In addition, detailed insights obtained through tracking increase awareness and motivate users to reduce waste. Basically, they prevent people from unnecessarily throwing away items and encourage them to reduce the amount of waste they generate in general (Woetzel et al., 2018).

Another approach to waste collection optimisation is to stop people from dumping waste in the containers that are meant for other types of waste or simply into the street, next to full rubbish bins. This is achieved through sensors that are placed inside bins to measure the current volume of rubbish and direct bin lorries to locations where they are needed. This not only enforces waste collection but also decreases the amount of energy consumed during collection, which leads us to the next trend (Woetzel et al., 2018).

5.2. Energy use optimisation

Since urbanisation is continuously growing, cities require more and more energy. As a result, urban areas consume over two thirds of the world's energy and generate around 70% of its greenhouse gas emissions. Although energy consumption is a complex problem, it can be reduced through the integration of interconnected smart solutions, which address the issue from multiple perspectives for the most effective results. The implementation of automated systems with smart meters and grids in commercial buildings and private households significantly optimises energy consumption as sensors collect data for the analysis of existing inefficiencies, while grids minimise energy loss in the transmission and distribution stages. In 2019 alone, 123 billion U.S. dollars were spent on smart grids, while investments in smart meters amounted to 21 billion U.S. dollars (Alves, 2022).

In addition, dynamic electricity pricing can be implemented through smart meters, which record energy consumption and communicate this data to suppliers. The collected data can be used for price differentiation based on the season and time of day. This approach is supposed to encourage end users to be more responsive and efficient, since all the information on their consumption and prices is visible in mobile apps. However, savings are not expected to be significant for private households. Optimisation could thus be further encouraged through various aspects to make consumers more aware of their energy usage. It could also be used to influence them to change their behaviour to decrease their energy consumption. At the same time, increased efficiency of energy delivery by smart grids could also decrease costs and create an incentive for lower consumption (Woetzel et al., 2018).

As the need and demand for electric vehicles (EVs) rises and consumers start using them more, the need for a charging infrastructure also increases. Even though consumers are mainly shifting to EVs for their environmental and economic benefits, there are some factors that are still limiting non-EV users when it comes to purchasing one, such as the fear that the battery will drain before they reach their destination, the lack of charging stations and long charging times. This is why it is expected that cities will have to act on this by setting up more charging stations in places where the frequency of people is high.

5.3. Air quality monitoring

The problem of air pollution is also extremely relevant nowadays. It is not surprising that many smart cities pay great attention to this issue and implement different solutions to overcome it. The increasing rate of CO2 emissions is the biggest concern in this field as it directly contributes to global warming. Many cities have developed certain strategies for the reduction of CO2 emissions, while some of them even plan to reach zero-emission levels in the near future. Some measures are taken on a bigger scale; for example, to cut carbon emissions by at least 55% by 2030, compared to the levels in 1990 (European Commission, 2021).

Thus, it is crucial to detect and monitor pollution levels. This helps to identify the most problematic areas and potential causes, allowing for the effective implementation of necessary preventive solutions. In addition, progress can be easily tracked in this way. In order to monitor air pollution, smart cities implement various technologies including IoT, integrating low-cost sensors, satellite data and data mining tools. Some countries use vehicles that are equipped with special detectors that analyse the air for various types of emissions. Pollution maps are then composed based on the acquired data. Mobile sensors are also gaining popularity in source estimation, health exposure assessment and creating awareness regarding the problem (Kaginalkar et al., 2021).

However, awareness cannot resolve the issue on its own. Data collected through these integrated technologies merely enables a city to make objective and informed decisions to improve the situation.

6. RESEARCH METHODOLOGY

To address the research question regarding how smart city services are perceived among the general population in Slovenia and Croatia, a sample of 1,390 Slovenian and Croatian residents was analyzed. Data collection was performed using an online survey tool. Data samples were collected over the course of ten months from June 2020 to March 2021. Altogether, 1,390 individuals completed the survey and provided data required for the analysis, while 2,937 individuals received the questionnaire. Descriptive statistics and mean comparisons were used for examining the differences between Slovenian and Croatian residents' perceptions of smart city services.

7. DATA ANALYSIS

The sample is made up of 1,390 respondents from Slovenia and Croatia, of which the majority are university students between the ages of 21 and 30, living in urban settlements (see Table 5.1).

Table 5.1: Profile of the respondents

		Share (%)
Gender	Male	37.4
	Female	62.6
Status	High school student	0.1
	Student	78.7
	Employed person	17.5
	Self-employed person	0.6
	Unemployed	0.6
	Retired	2.4
	Graduate	10.7
Age	Under 20	30.5
	21–30	51.1
	31–40	6.9
	41–50	5.9
	51–60	2.7
	Over 60	2.8
Highest level of formal education	Primary school	0.4
	Secondary school (4 years)	55.8
	Undergraduate programme/university (3 years)	24.6
	Graduate programme (2 years)	10.5
	Doctoral programme (PhD)	8.7
Type of settlement	Urban settlement	62.0
	Suburban settlement	20.0
	Small town or village	13.5

		Share (%)
	Scattered or secluded houses	4.5
Country of residence	Slovenia	45.7
	Croatia	54.3

First, a descriptive analysis of arithmetic means was conducted on the whole sample, followed by a comparison of means between Slovenian and Croatian residents. The topics of analysis were related to the respondents' perception of technology and the Smart City concept in general as well as to more specific smart-city-related issues, such as security and privacy issues, environmental issues, smart mobility, smart healthcare and citizen participation in the development of smart city services. Responses were mostly measured on a five-point scale, where one indicated the respondent strongly disagrees with the mentioned statement, and five indicated the respondent strongly agrees with it.

In the following paragraphs, we will present the results of the survey, divided into the following sections: interest in technology, smart cities, security and privacy in smart cities, smart mobility, environmental issues related to smart cities (together with the "influence on environmental issues on an individual's behaviour" and "privacy issues regarding air pollution sensors and energy consumption sensors"), waste pollution, noise pollution and light pollution.

7.1. Interest in technology

Considering their interest in technology, on average, all respondents agree that new technologies contribute to a higher standard of living. They are neutral about their use of new technologies, meaning, on the one hand, they are not too eager to experiment with them as soon as possible, while, on the other, they are also not hesitant to use them or wait for them to become accepted by the general public. Slovenians are waiting less than Croatians for technology to become generally accepted, whereas they are similar in other aspects of interest in technology.

Table 5.2: Individuals' interest in new technologies

Interest in technology	**Slovenia**	**Croatia**	**Total**
New technologies contribute to a higher standard of living.	4.3	4.1	4.2
I am among the first to use new technologies and experiment with them soon after they become available.	2.9	3.1	3.0
I am hesitant to use new technologies.	2.5	2.4	2.5
I am waiting until new technology use becomes unavoidable and is accepted by the general public.	2.6	2.9	2.8

Moreover, all respondents, on average, agree that the modern world is too dependent on smart technologies (Croatians a bit more than Slovenians), but, at the same time, they want their jobs to be related to smart technologies and believe they could be used to perform very complex tasks, such as planning, organising, designing, optimising resources or managing things and people (Croatians a bit more than Slovenians). They are neutral regarding their trust in smart technology capabilities for everyday decision-making processes.

Table 5.3: Individuals' attitudes towards smart technologies

Interest in technology	**Slovenia**	**Croatia**	**Total**
The modern world is too dependent on smart technologies.	3.5	3.9	3.7
I fully trust smart technologies in everyday decision-making processes.	2.9	2.9	2.9
Smart technologies could be applied to perform very complex tasks, e.g. planning, organising, designing, optimising resources, managing things and people.	3.6	4.0	3.8
I want my job to be related to smart technologies.	3.6	3.6	3.6

7.2. Smart cities

Concerning the smart city in general, all respondents on average somewhat agree that they are familiar with the Smart City concept (Slovenians more than Croatians), while they somewhat disagree that they are familiar with initiatives of their local government regarding the introduction of smart city elements. They somewhat agree that they would be happy to use smart city services in their personal, social and professional lives, that smart cities can improve their quality of life and that they are looking forward to living in a smart city. Moreover, they somewhat disagree with the statement that they would prefer to live in a city without smart city services.

Table 5.4: Individuals' attitudes towards the Smart City concept and services

Smart cities	Slovenia	Croatia	Total
I am familiar with the concept of the Smart City.	3.6	3.2	3.4
I would be happy to use smart city services in my personal, social and professional life.	3.7	3.6	3.7
I would prefer to live in a city that has no smart services.	2.4	2.6	2.5
I am familiar with the initiatives that my local government is facilitating regarding smart city elements.	2.5	2.6	2.6
I believe that smart cities can improve quality of life.	3.7	3.7	3.7
I look forward to smart cities being widespread.	3.5	3.6	3.5
I look forward to living in a smart city.	3.5	3.5	3.5

Regarding distinct smart city elements, all respondents on average agree with all smart city elements being included in their city, such as smart public transportation, a smart parking system, smart healthcare, smart street lighting, smart waste disposal and citizen-government interconnection. They most strongly agree with the implementation of smart waste disposal.

Table 5.5: Individuals' attitudes towards smart city elements

Smart city elements	**Slovenia**	**Croatia**	**Total**
Smart public transportation	4.2	4.2	4.2
Smart parking systems	4.4	4.2	4.3
Smart healthcare	4.1	4.2	4.2
Citizen-government interconnection	3.8	4.1	4.0
Smart street lighting	4.4	4.2	4.3
Smart waste disposal	4.5	4.4	4.4

Considering the use of sensors and smart devices in smart cities, all respondents are on average neutral about installing appliances with interconnected sensors in their homes (Slovenians agree more than Croatians). They somewhat disagree with the statement that they would be willing to use robots at work as well as in their daily lives (Croatians disagree more than Slovenians), since they believe that smart devices cannot make better decisions than humans (Slovenians agree more than Croatians). They would prefer to use smart devices for daily decisions, such as organising tasks or ordering food and clothes (Slovenians more than Croatians) rather than for making important decisions, such as choosing a field of study or turning down a promotion, but they are not keen on using smart devices for either of these.

Table 5.6: Individuals' attitudes towards sensors and smart devices

Sensors and smart devices	**Slovenia**	**Croatia**	**Total**
I do not mind installing appliances with Internet-connected sensors in my home.	3.3	2.8	3.0
I believe smart devices can make better decisions than humans.	3.0	2.5	2.7
I would allow a smart device to make daily decisions for me, e.g. organising tasks, ordering food and clothes.	2.7	2.2	2.4
I would allow a smart device to make an important decision for me, e.g. choosing a field of study, turning down a promotion.	1.9	1.9	1.9
I would be willing to use robots not only at work but also in my everyday life.	3.1	2.4	2.7

To summarise, Croatians are less keen on the implementation and use of sensors and smart devices for work and in daily life. Besides that, Slovenians and Croatians both do not agree with the use of sensors and smart devices for making important decisions for them.

7.3. Security and privacy in smart cities

Concerning security and privacy issues in smart cities, all respondents are on average most concerned about data privacy issues, security issues and the use of their data and preferences by other parties. They are neutral regarding the implementation of 5G networks but otherwise agree that there are security and privacy issues in smart cities. Nevertheless, they are not strongly concerned about it. There are no great differences between Slovenians and Croatians in their perceptions of security and privacy.

Table 5.7: Individuals' attitudes towards security and privacy issues in smart cities

Security and privacy in smart cities	Slovenia	Croatia	Total
Data privacy	4.2	4.1	4.2
Security issues	4.0	3.8	3.9
Transparency of services	3.1	3.4	3.3
Complexity of services	3.2	3.3	3.2
Historical records of activities	3.6	3.4	3.5
The use of my data and preferences by other parties	3.9	3.9	3.9
Implementing 5G networks	2.9	3.1	3.0
Democracy, transparency and consideration of interests	3.4	3.4	3.4

7.4. Smart mobility

Analysing smart mobility, all respondents on average somewhat disagree with smart-mobility-related issues, such as data collection and storage via smart devices, especially in cases where they do not see an immediate benefit from data sharing (e.g. discounts, access to information and so on). They also disagree with sharing their location and other personal data either with the government or agencies and companies. They are neutral regarding data sharing for the benefit of their community and somewhat agree with sharing data in exchange for the reduction of their cost of living. Slovenians and Croatians are quite similar in their perception of smart mobility.

Table 5.8: Individuals' attitudes towards smart mobility

Smart mobility	**Slovenia**	**Croatia**	**Total**
I do not mind smart devices collecting and storing my data.	2.5	2.5	2.5
I would be willing to share a larger amount of my data without expecting immediate mutual benefits.	2.1	2.3	2.2
I would be willing to share a larger amount of my data if it meant raising the quality of life of the whole community.	3.1	3.0	3.0
I would be willing to share a larger amount of my data if it meant a direct reduction in the cost of living, e.g. the price of water, electricity and heating.	3.4	3.2	3.3
I do not mind sharing information about my location.	2.3	2.4	2.3
I believe the government should be allowed to collect all personal data about its citizens.	1.9	2.3	2.1
I trust agencies and companies to keep my data safe and not exploit it.	2.6	2.6	2.6

7.5. Environmental issues with smart cities

Regarding environmental issues with smart cities, all respondents on average like the sustainable approach of smart cities and agree that they are trying to minimise their environmental footprint by using reusable bags, recycling waste, etc. They also try to avoid disposable products and live by sustainable principles but to a lesser extent. Slovenians are, in general, slightly more sustainability-oriented than Croatians, especially in recycling waste and their use of reusable bags.

Table 5.9: Individuals' attitudes towards the sustainability of smart cities

Individuals’ attitudes towards sustainability	Slovenia	Croatia	Total
I like the sustainable approach of smart cities.	4.1	3.7	3.8
I live by sustainable principles.	3.7	3.5	3.6
I try to pollute the environment as little as possible.	4.2	4.1	4.2
I use reusable bags.	4.2	3.9	4.0
I recycle waste.	4.3	3.7	3.9
I try to avoid disposable products.	3.6	3.5	3.5

Concerning air pollution in smart cities, all respondents on average are well aware of the air pollution issue and its impact on human health. They sense quite well when air pollution is high. Moreover, they strongly believe that their actions affect air pollution and that it is therefore also their duty to reduce it. Nevertheless, they do not always decide to buy more sustainable long-term useful items or alternatives, which lower energy consumption, although they do not disagree with it. Slovenians feel a slightly bigger obligation to the environment to reduce air pollution than Croatians, but they are otherwise quite similar in their attitudes.

Table 5.10: Individuals' attitudes towards air pollution in smart cities

Individuals’ attitudes towards air pollution	Slovenia	Croatia	Total
I am aware of the issue of air pollution.	4.4	4.2	4.3
I am personally aware when air pollution is high.	3.7	3.8	3.8
I believe it is my duty to the environment to reduce air pollution.	4.5	4.1	4.2
I believe that my actions affect air pollution.	4.1	3.8	3.9
I am aware that high levels of air pollution have an impact on human health.	4.5	4.3	4.4
When I decide to buy a long-term useful item, I try to look for alternatives that can lower energy consumption.	3.5	3.6	3.5

When I decide to buy a long-term useful item, I try to look for alternatives that contribute to sustainable development.	3.6	3.5	3.5

Examining the influence of smart cities on sustainability, all respondents on average somewhat agree that smart cities help prevent air pollution, climate change, excessive water use and that they reduce energy consumption. Slovenians agree with this slightly more than Croatians.

Table 5.11: Individuals' attitudes towards the impact of smart cities on sustainability issues

Individuals' perceptions of the impact of smart cities on sustainability	**Slovenia**	**Croatia**	**Total**
Smart cities help to prevent air pollution.	3.7	3.4	3.6
Smart cities help to prevent climate change.	3.5	3.3	3.4
Smart cities help to prevent excessive water use.	3.8	3.5	3.6
Smart cities reduce energy consumption.	3.7	3.5	3.6

Regarding air pollution sensors, all respondents on average expect air pollution sensors to work well for measuring air quality, humidity and carbon monoxide levels in households but do not understand or trust the information from sensors that well. They also do not agree strongly with the sensors collecting data. Nevertheless, they do not disagree with it. Slovenians and Croatians are quite similar in their perceptions of this.

Table 5.12: Individuals' attitudes towards air pollution sensors

Individuals' perceptions of air pollution sensors	**Slovenia**	**Croatia**	**Total**
I expect air pollution sensors to work well.	3.9	3.9	3.9
I understand the information provided by air pollution sensors.	3.2	3.4	3.3
I trust the information from the sensors is accurate.	3.6	3.5	3.5
I trust the information from the sensors is reliable.	3.6	3.5	3.5

I would use sensors for measuring air quality, humidity and carbon monoxide levels in the household.	3.8	3.6	3.7
I would use sensors for measuring air quality, humidity and carbon monoxide levels in the household, even if the data was recorded.	3.6	3.3	3.5

7.5.1. Influence of environmental issues on individual behaviour

Investigating the influence of environmental issues on individual behaviour, all respondents are on average not very keen on the use of air pollution sensors in their neighbourhoods. They somewhat agree that everyone in the neighbourhood having a personal sensor would improve their neighbourhood. They somewhat agree that the level of pollution would affect their attitude towards their neighbourhood and their planned activities in it. They are neutral regarding reporting their neighbours if they were polluting, and Slovenians and Croatians are quite similar in their attitudes towards this issue.

Table 5.13: Individuals' attitudes towards air pollution sensor use in their neighbourhoods

Individuals' beliefs about air pollution sensor use in their neighbourhoods	**Slovenia**	**Croatia**	**Total**
I believe having a personal air pollution sensor will improve my neighbourhood.	3.4	3.4	3.4
I believe everyone in my neighbourhood should have a personal air pollution sensor.	3.2	3.3	3.3
I believe high pollution in my neighbourhood will change my attitude towards my neighbourhood.	3.6	3.4	3.5
I will be motivated to consider information from the air pollution sensors while planning my activities in my neighbourhood.	3.6	3.4	3.5
I believe that I would report my neighbours if they were polluting.	2.7	3.2	2.9

7.5.2. Privacy issues regarding air pollution sensors and energy consumption sensors

Concerning privacy issues with air pollution sensor service providers, all participants are on average neutral about both their familiarity with the terms and conditions of their agreement with their service providers and regarding their trust in their provider's use of their personal data. However, they somewhat disagree with the service providers having direct access to their data and using it to make a profit. Croatians disagree with this more than Slovenians, while they are otherwise quite similar in their attitudes towards privacy issues with service providers.

Table 5.14: Individuals' attitudes towards privacy issues with service providers

Individuals' attitudes towards privacy issues with service providers	**Slovenia**	**Croatia**	**Total**
I am familiar with the terms and conditions of my agreement with service providers.	2.9	3.1	3.0
I am comfortable with my service providers having direct access to my data.	2.4	2.7	2.6
I am willing to allow my service providers to use my data so they can make a profit.	2.3	2.5	2.4
I trust my service providers to keep my data private.	2.9	2.8	2.9

Regarding privacy issues with the use of air pollution sensors, all participants on average agree that air pollution sensors will be used a lot in the future, but they only somewhat agree that they are trustworthy or safe in terms of privacy. Slovenians and Croatians are quite similar in their attitudes towards this issue.

Table 5.15: Individuals' attitudes towards privacy issues regarding the use of air pollution sensors

Individuals' attitudes towards privacy issues with air pollution sensor use	**Slovenia**	**Croatia**	**Total**
I find air pollution sensors to be trustworthy.	3.4	3.3	3.3
Air pollution sensor use is risky in terms of my privacy.	3.1	2.9	3.0
My privacy would be protected when using air pollution sensors.	3.2	3.1	3.2

I am concerned about my personal data when using air pollution sensors.	3.2	3.1	3.2
Air pollution sensors are something that will be used a lot in the future.	3.7	3.5	3.6

Investigating the use of data from air pollution sensors, all respondents on average strongly agree that they must be informed in advance of the potential use of their personal data from air pollution sensors as well as that misuse of their data must be prevented. They also agree that the data should not be passed to third parties and should be deleted after a certain amount of time. Moreover, they agree that the use of personal data for air pollution sensors should be limited. Slovenians and Croatians are quite similar in their attitudes towards this issue.

Table 5.16: Individuals' attitudes towards using data from air pollution sensors

Individuals' attitudes towards air pollution sensor data use	**Slovenia**	**Croatia**	**Total**
The use of personal data for the purposes of air pollution sensors should be limited.	3.8	3.7	3.8
Personal data related to the use of air pollution sensors should not be passed on to third parties.	4.1	3.9	4.0
The duration of the storage of certain personal data must be limited.	4.1	3.8	4.0
Misuse of personal data must be prevented.	4.6	4.3	4.4
Individuals must be informed in advance of the potential use of their personal data.	4.5	4.2	4.4

7.6. Waste pollution

Concerning waste pollution, all respondents on average agree with most of the waste reduction sanctions. They would decrease their waste production more if they were fined for it, compared to if their waste production became public or if they produced more waste than their neighbours. They would agree to deposit their waste in smart containers more if the waste bags were not linked to them. They would consider using sensors in their households to monitor and optimise waste collection. In general, they are not against smart waste management except for the use of waste bins that would sound an alarm when the dropped waste would not belong in them. Slovenians and Croatians are quite similar in their attitudes towards this.

Table 5.17: Individuals' attitudes towards waste pollution issues

Individuals' attitudes towards waste pollution management	**Slovenia**	**Croatia**	**Total**
If the volume of waste production in my household became public, I would try to decrease it.	3.5	3.4	3.4
If my neighbours' volume of waste production were lower than mine, I would decrease the volume of waste production in my household.	3.2	3.3	3.2
If households with greater waste production were fined, I would decrease waste production in my household.	3.9	3.6	3.7
I would be bothered by sensors that recognise what kind of waste has been thrown inside the bin and sound an alarm if the dropped waste did not belong in that bin.	2.7	2.9	2.8
I would be willing to deposit my waste in containers that are supported by sensors that can link waste bags to me.	3.1	3.4	3.2
I would be willing to deposit my waste in containers that are supported by sensors if the waste could not be linked to me.	3.6	3.2	3.4
I would use sensors in my household to monitor waste production to optimise garbage collection routes.	3.5	3.4	3.5

7.7. Noise pollution

Regarding noise pollution, all participants on average agree with the use of noise monitoring sensors for the purpose of detecting emergency critical crashes or glass breaking. They agree less with their use in public streets and any further use of the collected data. Slovenians and Croatians are quite similar in their attitudes towards this.

Table 5.18: Individuals' attitudes towards noise pollution issues

Individuals' attitudes towards noise pollution management	**Slovenia**	**Croatia**	**Total**
I would agree to my city installing noise monitoring sensors in public streets.	3.3	3.5	3.4
I would agree to the collected data being sent and analysed to better improve living in my city.	3.5	3.5	3.5
I would agree to noise monitoring sensors also detecting emergency critical sounds, such as car crashes or glass breaking.	3.9	3.7	3.8

7.8. Light pollution

As for light pollution, all participants on average agree that light pollution is problematic and would agree with weaker street lighting and their location being tracked for the sake of light-pollution reduction. They are neutral regarding the colour of streetlights. Slovenians agree with it a bit more than Croatians, but they are quite similar in their attitudes towards this.

Table 5.19: Individuals' attitudes towards light pollution issues

Individuals' attitudes towards light pollution management	**Slovenia**	**Croatia**	**Total**
Light pollution is problematic.	3.8	3.5	3.7
I agree with street lighting tracking my location to reduce light pollution.	3.6	3.3	3.4
I would oppose different-coloured street lights.	3.0	3.1	3.1
I would be for weaker streetlights, which would emit less light.	3.7	3.5	3.6

8. CONCLUSION

To summarise, Slovenians and Croatians are very keen on the development of smart cities and believe that new technologies can improve their personal and work life. Nevertheless, they are more interested in using smart technologies to perform very complex tasks at work than to make important life decisions. Their main points of concern are security and privacy issues regarding data collected by technologies. However, they see great potential in smart cities for solving environmental issues and are willing to change their behaviour to be more sustainable. Slovenians and Croatians are quite similar in their perceptions and attitudes towards digitalisation, sustainability and smart cities.

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CHALLENGES OF MANAGING A SMART CITY: AN ANALYSIS OF BUSINESS STUDENTS' PERCEPTIONS

6

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ABSTRACT

This chapter presents two case discussions of the Smart City concept in business classrooms. The first case was discussed at the School of Economics and Business of the University of Ljubljana in Slovenia. The second discussion on the same topic took place at the Faculty of Economics, Business, and Tourism of the University of Split in Croatia. The authors elaborate on the challenges that smart cities are dealing with and future challenges that business staff should be aware of and for which they should be prepared to provide appropriate solutions. The aim is to provide proposals for possible didactic approaches for presenting and moderating contemporary management topics, such as the incorporation of technology into the modern way of doing business. The authors also conducted a survey among students of both international institutions to examine their attitudes toward smart-city solutions. The findings show that business students feel both excitement as well as fear in relation to certain aspects of the Smart City. Therefore, it is essential to open the floor to discussions of students' attitudes toward the Smart City concept already in an educational environment so students will be well-equipped to handle challenges in implementing the Smart City concept in their future careers. The collaboration between the educational sphere and the business world is also beneficial for the developers of smart cities as they receive feedback from the public early on, when proposing solutions.

Keywords: Smart City, business students, management

1. INTRODUCTION

Over time, cities are becoming increasingly populated, and about two-thirds of the global population are expected to live in urban areas by 2050 (United Nations Population Fund in Hickman, Pierson & Comstock, 2021). From the inhabitants' perspective, the penetration of new technologies (i.e. cloud-based technology, the Internet of Things/sensors/wearables, mobile apps, biometrics/facial recognition, chatbots/natural language processing, virtual and augmented reality, Artificial Intelligence and machine learning, smart beacons/near-field communication, drones and robots, blockchain technology, etc.) in societies is the trigger for their higher adoption of the novel services provided by these technologies. However, implementing new technologies also brings challenges that makes adjusting to them more difficult for older generations (Garbin Praničević et al, 2017), whereas younger generations are being brought up using contemporary technology (Peterlin & Valentinčič, 2021).

In general, smart cities are cities that simultaneously develop and grow. Over time, different profiles of professionals have thought about and now know how to effectively use data and digital technologies to plan and manage the core functions of a smart city so that it can become and remain efficient, innovative, inclusive and resilient. Smart cities contain an indefinite number of different technologies that affect the quality of provided city services and consequently improve the quality of citizens' lives (Kirimtat et al., 2020). The integration of digital technologies, especially Artificial Intelligence, into urban systems and services presents new opportunities for bringing the city closer to its citizens (World Economic Forum, 2020). Although there is still no consensus on the size a city must reach or the technology it should include for it to be considered a "smart city", smart cities are generally considered to be technologically advanced cities that follow the goals of sustainability set by local, national and international standards to improve public services and achieve sustainable development (Slišković & Vrhovec, 2019). Within this context, digital technologies, such as a smart city platform, track and measure real-time demand for public transport, allow for optimisation based on real-time demand and reduce the cost of urban information management (Zhang, 2019).

Moreover, a smart city systematically applies digital technologies to improve the quality of life in the city, reduce resource consumption and increase the competitiveness of the regional economy in a long-term, sustainable way. For that purpose, smart cities integrate solutions for improving energy management, housing conditions, infrastructure, mobility, security as well as other services. The solutions are usually based on integrated sensor technologies, adding data analysis provisions and enabling related value-added processes. From an operational aspect, smart cities have created many opportunities for implementing smart solutions for waste management, reducing traffic congestion, increasing citizen safety as well as affordable housing, water management, smart building management, energy efficiency, renewable energy use and citizen participation. As expected, the projects that turn a city into a smart city are mostly complex and require new competencies to be developed by all stakeholders, such as understanding the impact of the application of digital technologies within urban development and the ability to develop integrated solutions that transcend existing boundaries (Gassmann et al., 2019).

Moreover, such projects, upon implementation, transform the core components of smart cities such as (Habibzadeh et al., 2019):

- *Smart Environments*, which are based on applications that provide a physical setup equipped with a large number of dedicated and nondedicated sensors, screens, drivers and processor-powered components, which are smartly integrated with everyday objects and connected via a network platform. The main factors for achieving a smart environment are adaptability, autonomy and effective communication with users.

- *Smart Homes and Buildings*, which focus on creating a comfortable home environment by controlling certain elements, such as energy management, which is done using a system that aims to reduce electricity bills by turning off certain appliances at peak times.

- *Smart Surveillance*, which focuses on the gradual but continuous reduction of sensor power consumption driven by the development of sensor technologies, which has enabled the use of various surveillance services.

- *Smart Transportation and Driving*, which includes vehicles equipped with sensory, communication, computing and process capabilities, which serve to improve safety, efficiency and service quality.

- *Smart Lighting*, which focuses on LED-based light sources, which adjust and harmonise spectral power and spatial distribution, as well as time modulation and polarisation and colour temperature. Adaptive light intensity control and the use of flashing traffic signs to warn drivers of danger are examples of popular smart-lighting technology.

- *Smart Parking*, which seeks to reduce the negative impact on the environment and finances by using a smart parking system based on the installation of road sensors or light sensors and cameras.

- *a Smart Grid*, which is an electrical grid infrastructure that uses data to create real-time models that participate in maintaining an optimal grid status. The data may include information on energy production and consumption, performance characteristics of distribution lines or the availability of energy sources.

On a different note, Giourka et al. (2019) have stressed that the introduction of new technologies will not be effective if citizens do not adopt them and get involved in further activities. Evidently, the Smart City concept is slowly but surely becoming the focus of various research interests mainly due to added values manifested in (1) better use of public resources, (2) an improved quality of services offered to citizens (Bondarenko, Oleynik, Biryukov, Tarando, & Malinina, 2020) and (3) a reduction of public administration operational costs (Medina, Pérez & Trujillo, 2017). Smart solution manufacturers on the one side and decision-making authorities on the other are both stakeholders that are responsible for ensuring the security of a deployed system, especially because security is recognised as the weakest link in the implementation of a smart city (Ijaz et al., 2016).

Accordingly, it seems reasonable to call on educators to upgrade study programmes with competencies that will enable young people (pupils, students, online course attendees, etc.) to be better informed, and later engaged as users and/or creators of smart city services as part of their professional experience.

2. SINERGY OF EDUCATION INSTITUTIONS' OUTPUT AND SMART CITY DEVELOPMENT

Following the above, we argue that the role of universities in the knowledge management of smart city projects is multifarious. Moreover, in line with Ardito et al. (2019), universities should act as intermediaries, gatekeepers, providers and evaluators of knowledge. Along the same lines, Ferraris et al. (2020, p. 168) have classified the university's role in the development of the smart city ecosystem as: “(1) [a] Source of knowledge (knowledge bank) – Provision and development of training programs that meet the standards of education of the 'smart' city; interactive learning, accessibility of scientific literature in the mode of remote access; (2) Supplier of qualified personnel – Training of specialists able to carry out innovative, managerial activities in the field of solving problems of an 'intelligent' city; (3) Developer – Providing opportunities for scientific and innovative activities, developing new business ideas, projects, technologies, for example, in the field of 'Internet of Things'; (4) Educational environment – Promoting the culture of the 'creative class', the formation of new cul–ural values; (5) Financial Mediation – Financing of the projects through helping in the presentation of smart city research proposals to national or supranational funds”.

Caldwell, Foth, and Guaralda (2013, p. 7) note the shift from the spaces of learning to places of learning through the direct engagement of local communities as a way to examine and learn from real-world issues in the city. The key goal is to promote the generation and exchange of urban design ideas for future development, which would inform the creation of new design policies responding to the needs of local citizens. The implementation of urban informatics techniques and approaches has promoted innovative engagement strategies. Urban informatics provides an innovative opportunity to enrich students' places of learning within a city.

Upon completing a literature review, we claim that continuous study programme upgrades should certainly provide students with relevant learning outputs i.e. the competencies to cope with certain up-to-date, evident weaknesses of smart cities, these being (1) a lack of uniform standards, which are necessary for the interoperability of city elements (Bašić et al., 2019); (2) a lack of a regulatory framework for the wider adoption of smart city services in practice (Weber & Podnar, 2019); (3) conflicts in which economic interests become more represented than environmental and societal interests (Trencher, 2019); (4) threats to privacy, censorship, surveillance and manipulation due to incomplete control and ownership of users' accounts (Heitlinger et al., 2019) and (5) ethical issues concerning data privacy, data surveillance and location monitoring and using cameras in public spaces (Kitchen et al., 2019).

3. METHODOLOGY

We distributed an online survey to business students at the University of Ljubljana and University of Split. One hundred and fourty-two (142) students responded to our questions, which focused on what their perception towards smart cities is. Fourty-three per cent (43%) of respondents were from the University of Split and 57% from the University of Ljubljana. The sample was composed of students aged 18– 26 (with 18-year-old students making up 7.1%; 19-year-old students 26.2%; 20-year-old students 17%; 21-year-old students 12.1%; 22-year-old students 10.6%; 23-year-old students 7.8%; 24-year-old students 10.6%; 25-year-old students 6.4%; and 26-year-old students making up 2.1%). Out of 142 students, 60.6% were female and 37.3% were male, while the rest preferred not to disclose their gender.

We adjusted the survey questions (SQs) based on several survey questionnaires: (1) questions such as "Which mode of transport is most useful to you?" and "Which technology have you already used (multiple answers are possible)?" were taken from the Smart cities survey – the UK city officials' survey (CBRE Research, 2018); (2) the questions "What do you see as being the top three forms of mobility in your city in the next five years?", "Would you be willing to trade reduced privacy for better services?", "How comfortable are you personally with sharing/allowing access to your personal data for the purposes of developing smart city technology?" and "What do you think are the biggest obstacles to smart city implementation?" were taken from a survey from Hickman, Pierson and Comstock (2021); (3) the question "With what smart city applications are you familiar?" (Lawhead, 2017); (4) the question "If you were a businessman/woman, what would be the top three technologies in which you would invest in the next two years?" (Team TTR, 2018); and (5) the questions "Do you expect the following technology suppliers will enable the digital transformation that will help create smart cities? (1 – very low trust in their ability; 5 – very high trust in their ability)"; and "Which technologies will take off in smart cities of the future?" (Pradeep, 2017).

4. FINDINGS

We present the key findings of our study below. In our first question, we were interested to know which mode of transport is most useful for our students. The results show (Figure 6.1) that students mostly use personal vehicles (67.7%). This can be interpreted in the context of the need to promote and develop public transport in smart cities more and make it accessible and desirable for young people in order to save resources and reduce pollution.

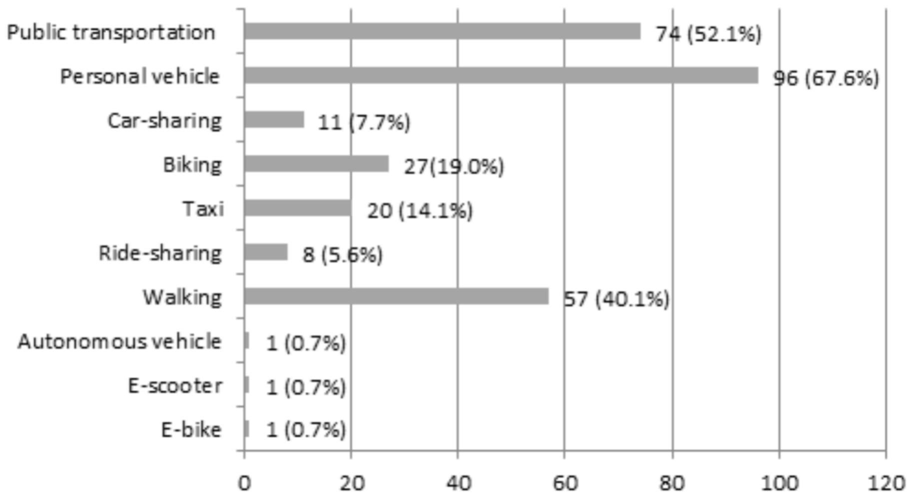

Figure 6.1: SQ "Which mode of transport is most useful to you?" (Author research, n=142)

Students expect public transportation, personal vehicles and biking to grow in popularity and become the top three forms of mobility in their cities in the next five years (Figure 6.2). Several initiatives have already been started in terms of introducing rental bikes, micromobility stations and car-sharing schemes in some Slovenian as well as Croatian cities.

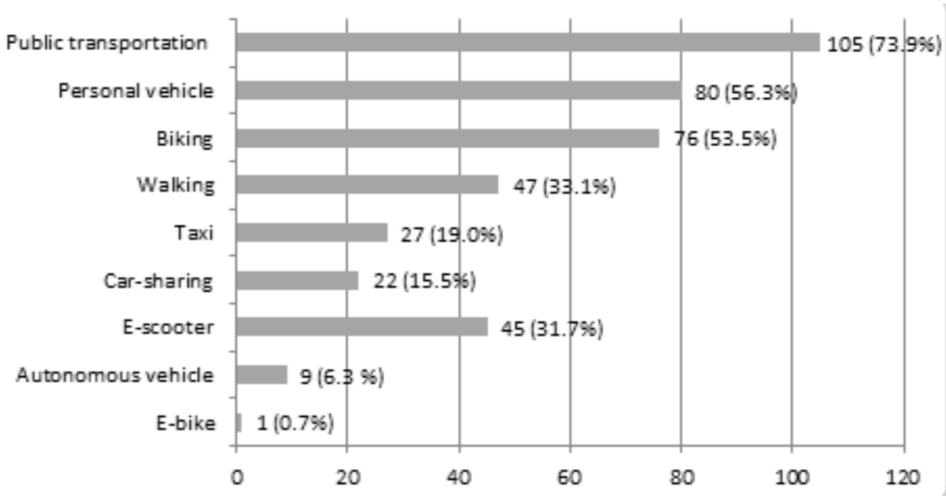

Figure 6.2: SQ "What do you see as being the top three forms of mobility in your city in the next five years?" (Author research, n=142)

Figure 6.3 shows what technologies business students already used. Mostly, they used mobile apps, cloud-based technology and the Internet of Things/sensors. Since we were conducting our survey at business schools, it should be noted that several students had already developed their own mobile apps as start-ups.

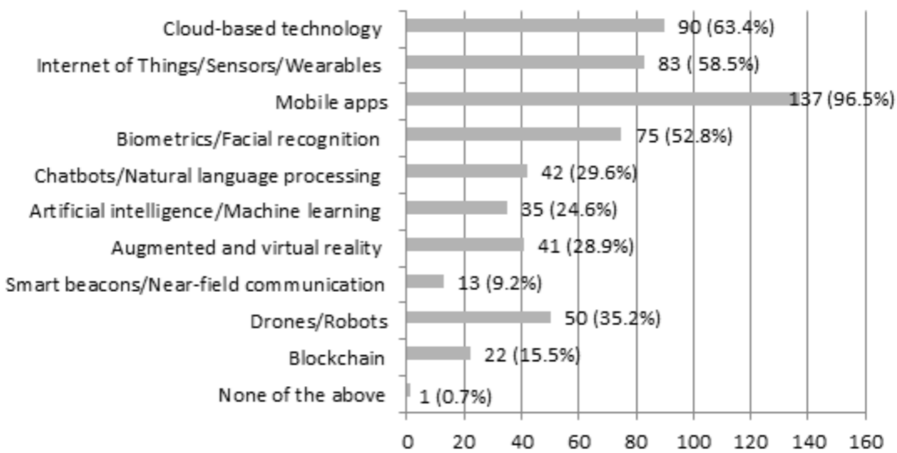

Figure 6.3: SQ "What technologies have you already used?" (Author research, n=142)

From the assortment of smart city applications, students are most familiar with parking management, street lighting and ride sharing (Figure 6.4). The

University of Ljubljana School of Economics and Business opened its own sustainable parking lot, called Park EF, in 2021 for which students can create their own accounts, allowing them to park their cars at a discounted rate. The system works by recognising registration plates and automatically taking money from students' accounts for the duration of their parking.

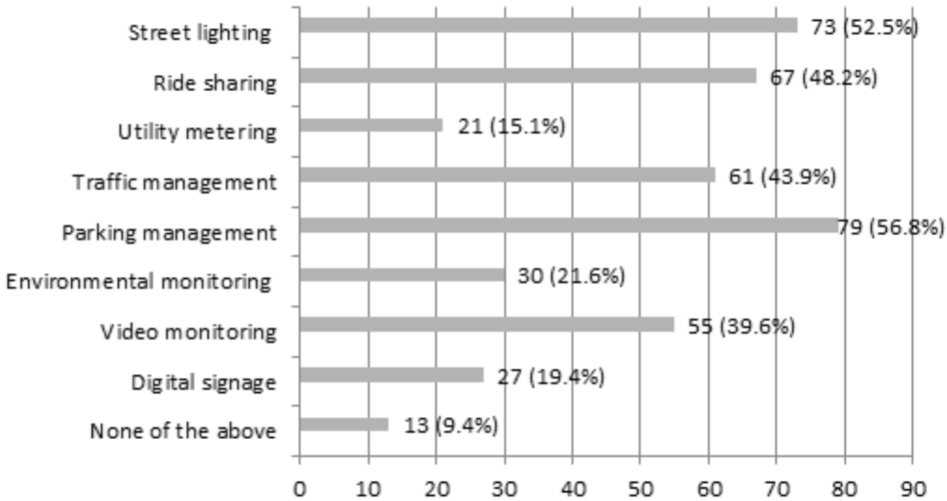

Figure 6.4: SQ "What smart city applications are you familiar with?" (Author research, n=142)

Smart cities represent different things to students, and they describe them in the following ways: (1) the smart city as a futuristic city with positive implications; (2) the smart city as a threat or means of domination and control; (3) the smart city as a combination of technological solutions that improve our lives; (4) the smart city as a way of enabling an ecological and clean way of living.

Students mostly associate smart cities with modern technology, robots and futuristic appliances. Even if they do not know any smart city specifically, they mostly still associate it with something from the future, something that we will need to think about more in the future and for which, to be able to function well in such a city, we will need to equip ourselves with the necessary knowledge. The category of "the smart city as a combination of technological solutions that improve our lives" is the most common among business students as the following quotes illustrate:

- "Automated and efficient available public services."

- "The city has technology to make living in the city easier."
- "A city where you *don't waste your time*."
- "When *technology eases living* in the city."
- "A city that has highly implemented *technology in its daily life*."
- "A city that is *well-organised with the help of technology*."
- "Automations, hassle-free processes."
- "Easier to find a route."
- "A city in which it is very easy *to go around and function.*"
- "It is a city in which technology helps with everyday inconveniences such as automatically opening rubbish bins."
- "Created to make people lazier than we already are."
- "That the city has useful *electronic/digital assistance for people.*"
- "*Temporary solutions applied to existing issues.*"
- "A set of public service solutions that help optimise daily processes in the city. For example, systems that help optimise traffic congestion on certain intersections."
- "An integration of IT and various aspects of city life (transport, parking, facilities such as hospitals, post offices, etc.)."
- *"Optimise city functions and promote economic growth."*
- "A smart city is a place where everything *runs smoothly* (e.g. traffic and internet)."
- "A smart city is a very modern and technologically upgraded area, with a prime aim to upgrade everyday life."
- "A city relying on IT infrastructure to optimise transport of people, goods, energy and information throughout itself."
- "A city where you can get all the needed information and services online."
- "Everything will be on apps (bus tickets, bike sharing...)."
- *"Digitalisation."*
- "Easy to live in."
- "More safety."
- "Clean."
- "A city that uses technology in all aspects of its infrastructure (streets, roads, parking)."
- "I would describe a smart city as a city where there is a lot of technology that is used to help people of all generations – not just younger people but technology available to elderly people. And in a smart city, it's important that people know how to use the technology that they have on hand."
- "You can use most of the city's services with apps on your phone and pay for them with credit cards (or over mobile)."

- "A city where everything goes smoothly, everything is electronic and full of smart devices such as different computers, robots..."

When we talk about novel things, we always fear how they will affect our lives. The fear is that new technology will become more powerful than humans or that we will lose control of some main aspects of our lives. The "smart city as a threat, means of domination and control" is another aspect of students' perceptions of the smart city:

- "Things can be monitored using phones."
- "*Full of cameras and prohibited access* to fundamental utilities; access available to people with smartphones."
- "A smart city is *controlled and managed by technology* in order to *improve the quality of life*."
- "*Digital Prison.*"
- "It means that technology will replace many human activities."

Surprisingly, when overcoming the fear of domination that technology could have over humans, students also grasp the positive aspects of smart cities, which can help us live more sustainably and in an environmentally friendly way. Students also see the potential of the "smart city to help us manage and sustain cities in a more ecological and clean way":

- "Sustainable, led by AI, with an emphasis on recent *technological advances, decentralized.*"
- "*Ecological and efficient.*"
- "*Ecological and clean.*"
- "*Emphasis on ecological aspects and technology.*"
- "A city that combines both a healthy environment and good communication."
- "A smart city means that, for transport, people would personally choose to use other, environmentally friendly ways of transport over conventional ones. Everything around us that is not yet included would be available on our personal devices quickly and efficiently to make our commute and everyday life easier."
- "Cheap, efficient, environmentally friendly."
- "A city with little traffic (artificial learning of managing traffic), low emissions, quick access to services (banks, emergency services, shops), few people working jobs that robots could do (shops without cashiers)..."

- *"Technologically advanced, better for the environment..."*
- *"[Has] more citizens and [is] environmentally friendly. You can access more things with your smart device. More automated."*
- "Smart city investments in human and social capital and traditional and modern communication infrastructure fuel sustainable economic development and a high quality of life, where natural resources are managed through participatory action."
- "A smart city enables its residents or other people to use modern technology for easier use of its services (by making data publicly available through Wi-Fi, using phones for certain reservations, minimising paperwork, providing faster access to services...)."

To some students, the whole concept of a smart city sounds "futuristic with positive connotations":

- "*A futuristic city.*"
- "A smart city is a city that is very modern and has a lot of high-tech technology and devices, and is very automated. *I think it would be very interesting to experience this kind of world to see how life would look."*
- "A smart city uses information and communication technology to improve operational efficiency and share information with the public. I think it is a *good idea* because a smart city is a more attractive place for residents to live and promotes a connected citizen experience."

Furthermore, 61.3% of students would like to live in a smart city, while 10.65% do not wish to live in one (Figure 6.5).

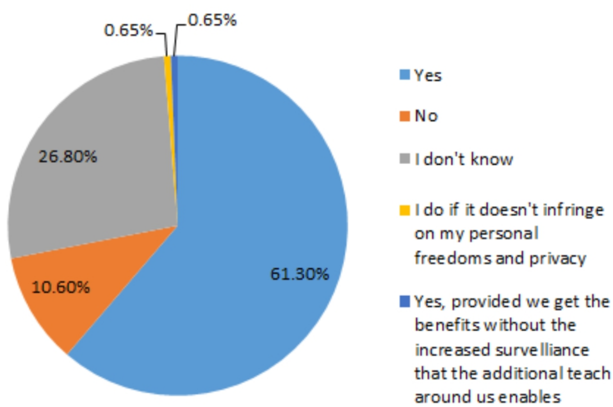

Figure 6.5: SQ "Do you wish to live in a smart city?" (Author research, n=142)

Students see large investment possibilities in mobile and network technology as well as big data analytics and sensor technology (Figure 6.6).

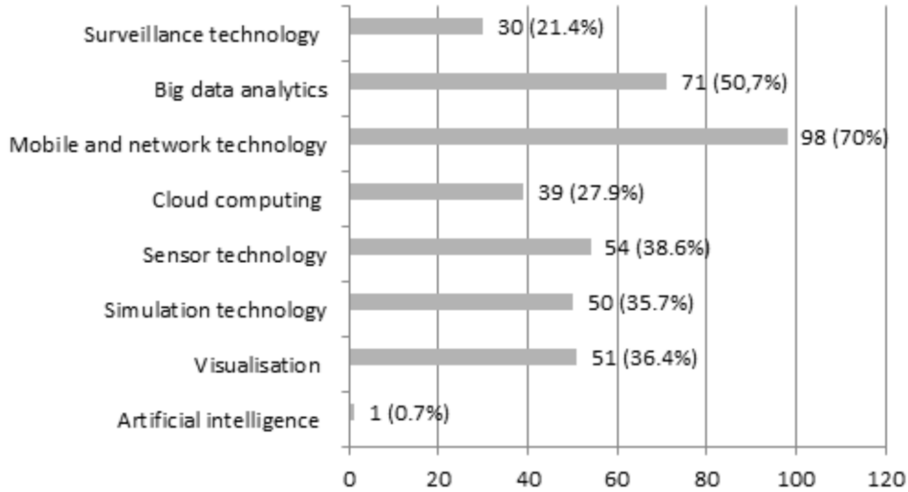

Figure 6.6: SQ " If you were a businessman/woman, what would be the top three technologies in which you would invest in the next two years?" (Author research, n=142)

Twenty-four students acknowledged that they do not know even one smart city. Being among the most recognised smart cities, ten students named Tokyo because of its well-organised public transportation:

- "What fascinates me is the amount of solutions they provide for certain ongoing problems, but, at the same time, it scares me a little bit because I feel the price for that is decreased well-being and interpersonal connection due to the amount of work that is demanded and the stimulation that technology provides. In my opinion, it is really up to the individual to smartly use and not abuse these things, and I feel that some education on the subject is needed for this."

- "I think Tokyo is a good example of a smart city, or any bigger cities in Japan or Korea. It's just because the cities are in another country, and I'm fascinated by their culture. They have so many new and improved things with public transportation the likes of which cannot be found anywhere else around the world."

Nine students recognised Singapore as the most well-known smart city as it has used technology to make life easier for its citizens. Five students perceived

Dubai as a smart city because it strives for sustainability and it uses technology for traffic routing, parking, infrastructure planning and transportation. They also use telemedicine and smart healthcare.

Among the cities that students perceived as smart cities are also Amsterdam, Barcelona, Beijing, Bilbao, Graz, Kranj, Ljubljana, London, Los Angeles, Madrid, Maribor, Moscow, Munich, New York, Oslo, Pardubice, Paris, Rotterdam, Seoul, Shanghai, Split, Vienna, Vrgorac and Zagreb.

One interesting example is provided by a student who is fascinated by the partnership ecosystem in the smart city of Pardubice:

- Pardubice (Czech Republic) uses new technologies that improve the functioning of the urban ecosystem. Thanks to new technologies, the operation of the city is simpler, more environmentally friendly and energy efficient. What fascinates me is that it is not that big a city, and, still, it is able and trying to do its best to be a smart city. Another thing is student involvement and that of local people. For example, the local University of Pardubice, specifically the Faculty of Electrical Engineering and Informatics, also took part in the Pardubice project.

Students perceive that 5G, Artificial Intelligence, machine learning and mobile phone apps will take off in smart cities (Figure 6.7).

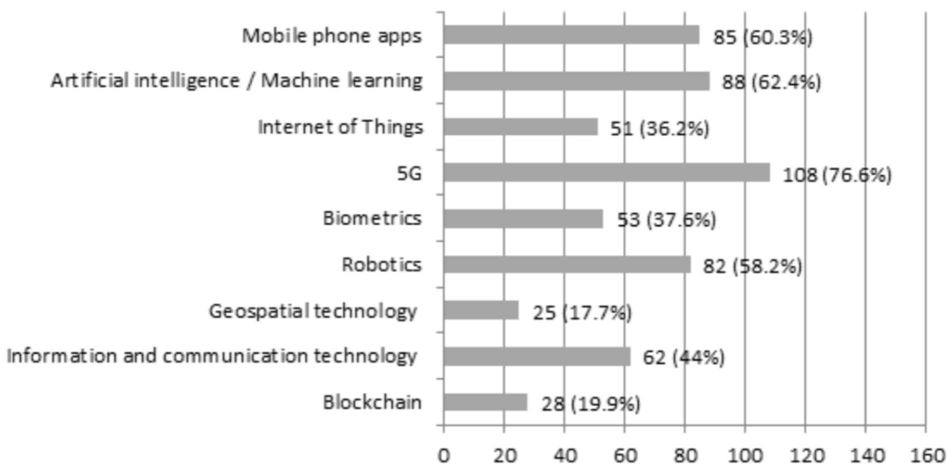

Figure 6.7: SQ "Which technologies will take off smart cities of the future?" (Author research, n=142)

Fifty-two point two per cent (52.2%) of students are not willing to trade privacy for better service (Figure 6.8). When we asked the additional question of "How comfortable are you personally with sharing/allowing access to your personal data for the purposes of developing smart city technology?", 59.9% of students said "no" (Figure 6.9).

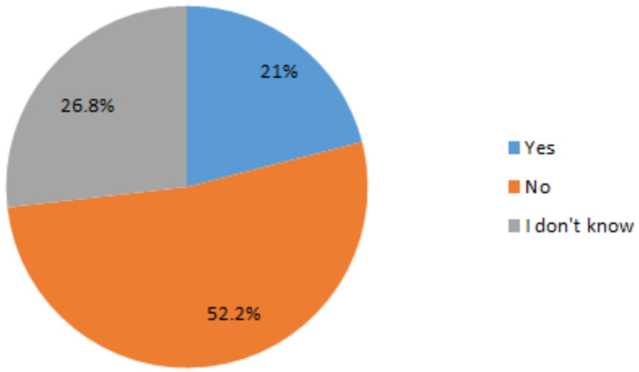

Figure 6.8: SQ "Would you be willing to trade reduced privacy for better services?" (Author research, n=142)

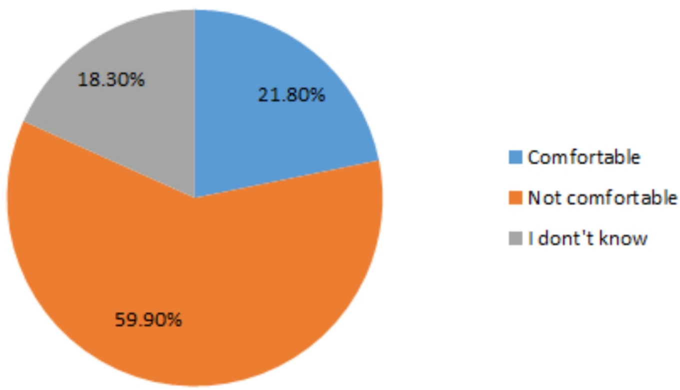

Figure 6.9: SQ "How comfortable are you personally with sharing/allowing access to your personal data for the purposes of developing smart city technology?" (Author research, n=142)

Students perceive that financing, national security concerns and the sharing of data enable new technologies (Figure 6.10).

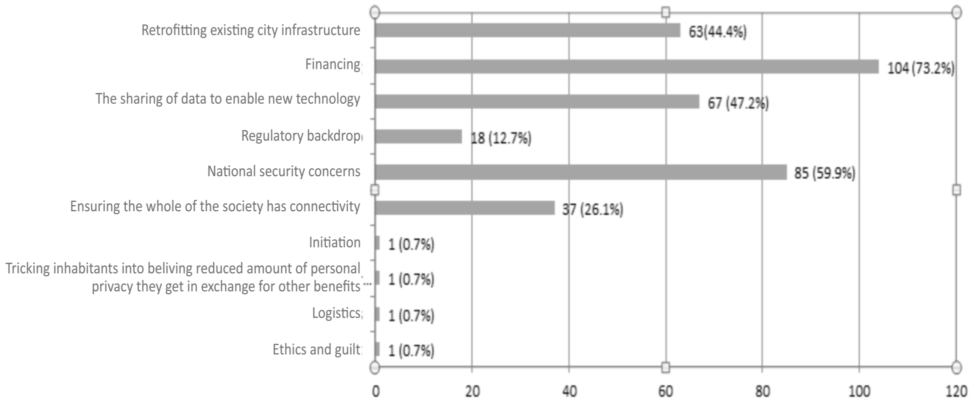

Figure 6.10: SQ "What do you think are the biggest obstacles to smart city implementation?" (Author research, n=142)

5. DISCUSSION AND CONCLUSION

The number of challenges that smart cities are dealing with is growing and, over time, are coming to be imperative for current business students. Respectively, graduates need to be prepared as much as possible to face them and consider the topic from a broader perspective. In that context, some related reflections and considerations derive from these research results.

Bearing in mind that climate change is the key challenge being addressed in our time (European Environment Agency, 2021), the use of personal vehicles (Figure 6.1) as the most used mode of transport is not the most optimal solution. However, comparing the same questions with CBRE Research (2018) provided by officials in 14 UK cities, the CBRE findings are only slightly more favourable and indicate that personal vehicles are the second most used means of transportation, just behind public transport. Yet, one reassuring fact is that the mode of transport to which students suppose their city's residents will gravitate the most in the short term is dominantly public transport, along with a significant growth in biking and e-scooter use (Figure 6.2).

The more technology – like mobile apps, cloud-based technology and the Internet of Things/sensors (as presented in Figure 6.3) – is used, the better it will be understood and even accepted. This has been confirmed in the study of smart service platforms that facilitate social creativity (Anttiroiko et al., 2014). Along the same lines, the more familiar people get with the assortment of smart city applications (such as parking management, street lighting and ride sharing, as presented in Figure 6.4), the larger the amount of positive social change driven by ICT adoption that is expected and the wider the understanding of smart cities and their specifics (Kummitha & Crutzen, 2017).

Given that just over 60% (Figure 6.5) of respondents expressed a desire to live in a smart city, stakeholders, public administrators and educators in particular, need to support the efforts that address smart cities weakness (Bašić et al., 2019; Heitlinger et al., 2019; Kitchen et al., 2019; Trencher, 2019; Weber & Podnar, 2019), as mentioned previously in this chapter. However, the core question remains whether fixing the downsides would significantly affect the tendency towards maintaining privacy, which is, according to our findings, high (as summarised in Figures 6.8 and 6.9). Censorship, surveillance, manipulation due to incomplete control and ownership over users' accounts as well as threats to privacy are all areas that have not been sufficiently explored, which presents an opportunity for new research. To this, we may add a call for further research into the possible links between data sharing and threats to national security, as suggested by the results of this study (Figure 6.10).

Taking into account the rising trend toward digital governance of data-driven smart cities (Dubman, 2019), there are many opportunities for major investment in mobile and network technology, big data analytics and sensor technology (as presented in Figure 6.6). In that context, it is expected that the number of investors in these technologies will grow (CB Insights, 2021).

Finally, respecting that 5G, artificial intelligence, machine learning and mobile phone apps will take off in smart cities (as presented in Figure 6.7), and, in line with many recent studies' outputs (Allam & Dhunny, 2019; Almao & Golpayegani, 2019; Guevara & Auat Cheein, 2020; Nosratbadi et al., 2019; Voda & Radu, 2018), we repeat and highlight once more the important role of universities in training/educating future staff to solve problems using technology and not just use it for the sake of using it.

What contributes to this is the perception of the university as a mediator of knowledge (Ardito et al., 2019) that offers a wide range of roles and occupations required for the development of smart city ecosystems (Ferraris et al., 2020).

The smart city can be presented to students through the following learning modality mechanisms, within corporate as well as educational institutions: (1) virtual classroom learning about how smart cities function and the technology needed for this (facilitator-led with two-way interactions but no need for co-location); (2) instructor-led (facilitator-led to allow for in-person interactions); (3) academic courses on specific aspects of smart cities (internal or external series of structured courses/content, possibly for academic credit); (4) a programme organised in collaboration with the mayor of a chosen smart city (structured learning focused on a topic, capability, role, etc.); (5) discussion boards on topics concerning smart city technology that produces fear or excitement (online, with study groups, discussions and questions); (6) collaboration tools (learners can identify peer "experts", search peer-generated content and share their own resources); (7) peer feedback on own experiences with the technology and benefits that smart cities offer (peers review and providing feedback to other peers to enable students to learn from one another); (8) coaching/mentoring by smart city experts from different disciplines (one-on-one interactions to provide support and reinforcement); (9) web-based (e-learning to reach large numbers of dispersed learners); (10) job aids for new professions that smart cities need (when needed, self-study materials to provide information for the learner, such as quick-reference guides); (11) podcasts and videos of smart city cases (internal or external content focused on market trends, management skills and more); (12) interactive support (an internal support team to answer day-to-day questions via phone or online chat); (13) QR codes/beacons (geo-based activities connecting learning to a specific location); (14) voice recognition (hands-free technology providing access to information without stopping work); and (14) mobile learning (mobile access to learning platforms) (Deloitte, 2022).

Teaching staff could collaborate more closely with identified good practice role models of smart cities, such as Algiers, Allahabad, Amsterdam, Changsha, Dehradun, Ēvora, Hangzhou, Johannesburg, Leuven, Nagpur, Nara, Newark, Porto Alegre, Pune, Quayside, Singapore, Torino, and Trikola. (Anthopoulos, 2019). The city of Vienna (Roblek, 2019) was also identified as a smart city in the nearby vicinity of Slovenia and Croatia. Therefore, excursions could be arranged to show students the characteristics of a functioning smart city nowadays and the challenges they are facing, which students could help solve.

We wish to conclude with a quote from one of the participants:

- "I didn't know that smart cities exist already and was fascinated that they do exist at present and that they even exist in my country. We think that students need to be introduced to the concept of the smart city in a business classroom as it will affect their everyday lives as well as provide professional opportunities in the near future."

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CRITERIA EVALUATION FOR SELECTING IoT PLATFORMS IN SMART CITIES: EVIDENCE FROM CROATIA AND SLOVENIA

7

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ABSTRACT

The growing interest in the smart city paradigm has recently led to additional research and business-related inquiries. Considering the implementation of the Internet of Things (IoT) platform in smart cities, it is critical to pick a relevant platform that meets all criteria. This chapter, therefore, identifies the relevant criteria for selecting an IoT platform and presents the most important ones. The survey was conducted in Croatia and Slovenia, where both end users as well as vendors evaluated the importance of the proposed criteria. These two sources form the database for the empirical comparison of the two neighbouring countries of Southeastern Europe. The results indicate the presence of several evaluation differences between end users and vendors as well as between vendors in Croatia and Slovenia.

Keywords: Internet of Things, Smart City, criteria, Slovenia, Croatia

1. INTRODUCTION

The Smart City (SC) concept has recently received a lot of attention. The number of papers has expanded dramatically in the last seven years, according to a Scopus database search conducted in February 2022. This indicates that more research and practical application of the above-mentioned notion are required. A smart city, according to the European Commission, is "a place where traditional networks and services are made more efficient via the use of digital and communications technology for the benefit of its residents and businesses" (EK, 2020). Digital and telecommunication technologies cannot be used in isolation; for a city to become smart, it must have a high level of information technology integration and broad use of information resources (Kim, Ramos & Mohammed, 2017).

The new, emerging concept of the Internet of Things (IoT) has become a vital element when considering the future of information and communication technologies (ICT) (Kim & Kim, 2016). It enables remote monitoring, managing and controlling of devices as well as creating knowledge from real-time data (Kim, Ramos & Mohammed, 2017; Nunes et al., 2017; Alelaiwi, 2019). The IoT can be viewed as an ecosystem that links physical objects (sensors) to telecommunication networks, bridging the gap between the physical and virtual worlds and enabling the creation of new services and applications (Nunes et al., 2017). The IoT assumes installing and connecting sensors to the Internet through specific protocols for information exchange to accomplish intelligent recognition, location, tracking, monitoring and management (Kim & Kim, 2016; Silva & Jardim-Goncalves, 2021). Successful implementation of IoT platforms could bring significant benefits, e.g. efficiency, effectiveness, safety, security and quality decision-making (Kim & Kim, 2016). In addition, IoT platforms are the most crucial component of the IoT concept because they bridge the gap between device sensors and data networks. The platform links data to the sensor system and provides insights via back-end apps, allowing users to obtain a sense of the enormous amount of data flowing in from various sensors (Nunes et al., 2017).

A wide range of IoT integration platforms have recently become available (Abdelmegid at al., 2020), and the number of platform providers (vendors) is therefore also growing. Furthermore, the Gartner research company (2020) expects the global government IoT endpoint electronics and communications market to reach $17.4 billion in 2021 (Gartner, 2020). Relevant IoT end users in the smart city (e.g. city administrators, managers, decision makers and policy planners) need to answer crucial questions related to the selection of the IoT platforms that are to be implemented. Different IoT technologies in smart cities enable the utilisation of different devices, which would increase the life quality in cities as well as the efficiency of various daily services (Nižetić et al., 2020). Selecting the most suitable platform for individual users is a critical challenge (Mashal, Alsaryrah & Chung, 2020). The literature shows the existence of few criteria and alternatives when selecting an IoT platform, where neither is dominant (Contreras-Masse et al., 2019).

Given the above, the motivation of this chapter lies in a practical and theoretical need to investigate whether commonly used criteria for the selection of technology, in general, are applicable for IoT platforms as a part of the Smart City concept. In addition, the presented study aims to answer the derived research question of whether differences exist in the perceived importance of IoT platforms' selection criteria between end users and vendors in Croatia and Slovenia. This research gap has been partially addressed by Mijač, Ninčević Pašalić and Tomat, 2021. However, future research directions refer to expanding the number and diversity of participants as well as including some vendors and smart city managers in wider geographical regions (Slovenia). With this chapter, the authors fill the research gap by including non-IT experts in evaluating the criteria and comparing previously collected data with another geographical area – Slovenia. This approach has not been presented before to the best of our knowledge.

The environment considered for this study includes the smart cities of Croatia and Slovenia. As stated previously, a city could be considered "smart" if it has a project in one or more of the six dimensions (Giffinger & Gudrun, 2010). Taking a stricter approach based on smart city maturity levels (EU, 2014), research conducted on the 20 largest Croatian cities (over 25,000 inhabitants) confirmed that only four cities (20%) meet this criterion and thus can be categorised as a smart city, while two more are in the process of developing their smart city strategies (Ninčević Pašalić, Jadrić & Ćukušić, 2020). As for Slovenia, authors (Pušnik et al., 2019) consider Ljubljana, Maribor, Koper and Kranj to be smart cities (which is approximately 20% of the 20 largest Slovenian cities).

The rest of the chapter consists of five sections. Section two gives a theoretical background on the IoT domain, IoT platform and criteria used. Section three shortly introduces the methodology used, while section four presents the results of the evaluated criteria. Sections five and six discuss the results and conclude the chapter with final remarks, listed limitations and avenues for future research.

2. THEORETICAL BACKGROUND

The main goal of IoT technologies is to simplify processes in different fields, ensure better efficiency of systems (technologies or specific processes) and improve quality of life (Nižetić et al., 2020).

Small sensors implanted in smart items such as electronic devices, alarm systems, cars, home appliances and industrial machines make up the Internet of Things system, which allows them to communicate with one another and with their surroundings (Nunes et al., 2017). Because the Internet of Things domain is even more innovative than the Smart City concept itself, the articles that exist on criteria selection are primarily based on literature reviews. Technology, markets and laws, for example, have all been studied in the past (Baumgärtner & Winkler, 2003). Furthermore, as the authors point out, there has been minimal research on the interoperability of IoT platforms from a business-value perspective, taking into account both technical and nontechnical elements as selection criteria for adopting such platforms (Abdelghaffar & Abousteit, 2021).

Other authors have presented a multi-criteria approach using three main criteria for IoT applications (Kim & Kim, 2016): (1) technological prospects, (2) market potential and (3) regulatory environment. A recent paper points out that smart objects differ in their technical specifications due to their variations in design and features; thus, specific subcriteria can also be derived (Mashal, Alsaryrah & Chung, 2020).

Their conclusions may be limited from a methodological standpoint because they rely on respondents who are primarily experts with ICT backgrounds. Furthermore, several authors have offered a systematic framework for evaluating the IoT, although empirical research is lacking in the literature (Silva & Jardim-Goncalves, 2017). A literature review analysis confirmed that different criteria could be found depending on the type of technology (e.g. database, cloud, etc.). Even though interoperability as a criterion is especially highlighted when considering the selection of smart objects (Mashal, Alsaryrah & Chung, 2020), it could be considered within the criteria of integration flexibility and standardisation. The list of criteria, information about the IoT domain and authors who have investigated the criteria are summarised in Table 7.1.

Table 7.1: IoT selection criteria

Criteria	***Authors***
Platform reliability	(Kim & Kim, 2016; Kondratenko, Kondratenko & Sidenko, 2019; Mashal, Alsaryrah & Chung, 2020)
Platform price	(Kim & Kim, 2016; Singla *et al.*, 2018; Lin et al., 2020)
Standardisation	(Kim and Kim, 2016)
Platform scalability	(Lin et al., 2020)
Platform security	(Kondratenko, Kondratenko & Sidenko, 2019; Lin et al., 2020)
Platform usability	(Thomas, Onyimbo & Logeswaran, 2016; Alelaiwi, 2019; Lin et al., 2020; Mashal, Alsaryrah & Chung, 2020)
Integration flexibility	(Kondratenko, Kondratenko & Sidenko, 2019; Lin et al., 2020)
Platform availability	(Singla et al., 2018; Lin et al., 2020; Mashal, Alsaryrah & Chung, 2020)
Platform security	(Kim & Kim, 2016; Kondratenko, Kondratenko & Sidenko, 2018; Uslu et al., 2019; Lin et al., 2020)
Device management	(Kondratenko, Kondratenko & Sidenko, 2019)
Platform functionalities	(Kondratenko, Kondratenko & Sidenko, 2019; Lin et al., 2020)
Usefulness of visualisation	(Kondratenko, Kondratenko & Sidenko, 2019)
Variety of data analytics tools/possibilities	(Kondratenko, Kondratenko & Sidenko, 2019)
Platform portability	(Alelaiwi, 2019)

Supportability (from vendor/provider)	(Alelaiwi, 2019)

Source: adapted from Mijač, Ninčević Pašalić & Tomat (2021)

Criteria that were deemed irrelevant (outside of the scope of an IoT platform) were omitted from the analysis, leaving the authors to concentrate solely on the general ones (e.g. market longevity). The literature review yielded the following 15 criteria: availability, security, price, reliability, device management, integration flexibility, manufacturer quality, portability, scalability, standardisation, supportability, functionality, usability, visualisation utility and data analytics variety.

3. METHODOLOGY

In the process of decision making, decision maker(s) evaluate the importance of criteria in terms of priorities or weights. In this study, group weight assessment has been conducted with experts. Using the grading method, vendors and end users (in the role of experts) were presented with criteria and were asked to award a grade for each criterion in an interval from 0 to 100. The weight was calculated using the following formula (1):

$$w_{jk} = \frac{p_{jk}}{\sum_{j=1}^{n} p_{jk}} \quad (1)$$

$$w_j = \frac{\sum_{k=1}^{l} w_{jk}}{\sum_{j=1}^{n} \sum_{k=1}^{l} w_{jk}} \quad (2)$$

where *n* signifies the number of alternatives, p_{jk} the grade from expert *k* to criteria *j*, w_{jk} signifies the normalised weight calculated for criterion *j* from expert *k*, and w_j (2) stands as the total weight for criterion *j*. The weights are required for multi-criteria decision making (MCDM), which is a decision-making system known for its use with conflicting criteria and a limited number of alternatives (Babić, 2017).

The research instrument was prepared by the authors following the results of the literature review. It contained the essential criteria (N=15) for selecting an IoT platform that required expert grading. Additionally, experts were asked to add any other criterion in case they thought any were missed by the authors.

Subsequently, a descriptive comparison of Croatian and Slovenian results was done, as described in section 4.

4. RESULTS

In total, 16 experts participated in the evaluation, half of whom were end users (N=8) and the other half vendors (N=8). Half of the participants are from Croatia and half from Slovenia. The results of the experts' evaluations yielded three additional criteria: a customer support team, an intuitive user interface and privacy/data protection. However, all of these could be seen as being contained within the listed criteria (Table 7.1). Criteria weights were calculated for each group of experts as well as each country and sorted starting from the highest-rated criteria.

Croatia

Calculated and sorted weights for Croatian vendors and end users are shown in Table 7.2.

Table 7.2: Criteria weights according to vendors and end users in Croatia

Criteria	***Weight according to vendors***		***Criteria***	***Weight according to end users***
Device management (w7)	0.079113		Platform functionalities (w3)	0.079803
Platform scalability (w13)	0.078988		Platform security (w12)	0.077991
Platform security (w12)	0.078595		Platform scalability (w13)	0.075378
Platform price (w1)	0.078115		Platform portability (w10)	0.075338
Platform functionalities (w3)	0.076955		Device management (w7)	0.073527
Platform usability (w15)	0.072585		Platform usability (w15)	0.071295

Platform reliability (w9)	0.069821		Variety of data analytics tools/possibilities (w11)	0.068741
Platform portability (w10)	0.068907		Platform price (w1)	0.066489
Variety of data analytics tools/possibilities (w11)	0.06439		Platform reliability (w9	0.065058
Usefulness of visualisation (w6)	0.05993		Integration flexibility (w5)	0.064618
Integration flexibility (w5)	0.05868		Usefulness of visualisation (w6)	0.062425
Platform availability (w2)	0.055584		Platform provider quality and reputation (w4)	0.057639
Standardisation (w14)	0.055387		Platform availability (w2)	0.056438
Platform provider quality and reputation (w4)	0.051923		Supportability (from vendor/provider) (w8)	0.053536
Supportability (from vendor/provider) (w8)	**0.051026**		Standardisation (w14)	**0.051725**

As seen in Table 7.2, the most important criteria for end users while selecting the IoT platform is functionality. It is interesting to point out that, except for the criterion of price, every other criterion has been rated as more important by IoT vendors than it has been by end users. Unexpectedly, price is considered a more important criterion by vendors than end users in Croatia. However, security and scalability are perceived as among the top 20% criteria by both vendors and end users.

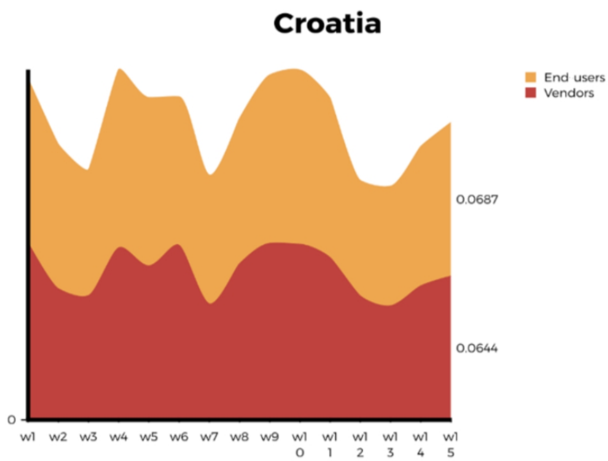

Figure 7.1: Comparison of weight between vendors and end users in Croatia

Slovenia

Calculated and sorted weights for vendors and end users from Slovenia are shown in Table 7.3. Values are sorted from the highest to the lowest. It can be seen that, when taking into consideration the top-20% criteria, only one criterion is common for end users and vendors in Slovenia – platform functionality.

Table 7.3: Criteria weights according to vendors and end users in Slovenia

Criteria	***Weight according to vendors***		***Criteria***	***Weight according to end users***
Platform availability (w2)	0.090967943		Platform functionalities (w3)	0.078149
Platform reliability (w9)	0.088846289		Platform security (w12)	0.077481
Platform functionalities (w3)	0.07691157		Platform scalability (w13)	0.076901
Platform usability (w15)	0.076407563		Platform usability (w15)	0.074301
Platform price (w1)	0.07280326		Integration flexibility (w5)	0.073976

Platform security (w12)	0.072086251		Platform availability (w2)	0.072052
Supportability (from vendor/provider) (w8)	0.071640406		Platform price (w1)	0.068501
Integration flexibility (w5)	0.069923261		Platform portability (w10)	0.068402
Device management (w7)	0.063408224		Device management (w7)	0.065366
Standardisation (w14)	0.061395405		Variety of data analytics tools/possibilities (w11)	0.063541
Platform scalability (w13)	0.061162562		Platform reliability (w9)	0.062185
Usefulness of visualisation (w6)	0.057525871		Usefulness of visualisation (w6)	0.060929
Platform portability (w10)	0.053895405		Standardisation (w14)	0.05718
Variety of data analytics tools/possibilities (w11)	0.047339033		Platform provider quality and reputation (w4)	0.051097
Platform provider quality and reputation (w4)	**0.035686955**		Supportability (from vendor/provider) (w8)	**0.049938**

Calculated weights for each criterion are graphically presented in the figure below (Figure 7.2).

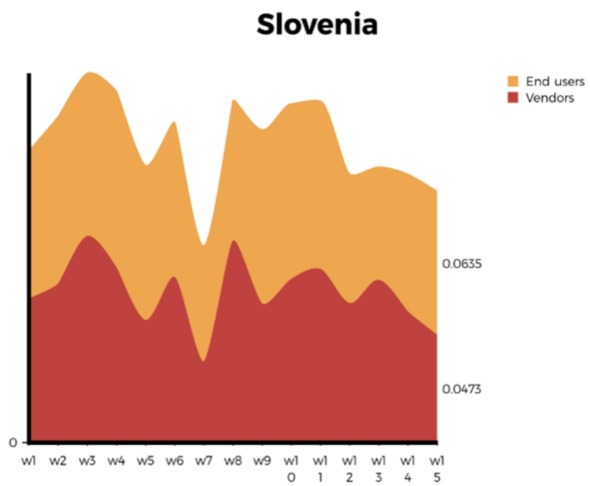

Figure 7.2: Comparison of weight between vendors and end users in Slovenia

Comparison

Calculated criteria weights according to vendors in Slovenia (SLO) and Croatia (CRO) have been compared and shown in the table below (Table 7.4).

The top 20% of the highest weights are coloured green, while the bottommost 20% in terms of value have been marked by red cells. After observing the calculated values, it can be stated that vendors agree only on one criterion – platform provider quality and reputation – which had the lowest grade. According to this, it can be said that the agreement level between vendors is 1% (1/15).

Table 7.4: Croatian and Slovenian vendors

Criteria	**Vendors SLO**	**Vendors CRO**
Device management	0.063408224	0.079113189
Integration flexibility	0.069923261	0.0586795
Platform availability	0.090967943	0.055584428
Platform functionalities	0.07691157	0.076955329
Platform portability	0.053895405	0.068907204
Platform price	0.07280326	0.078115165
Platform provider quality and reputation	**0.035686955**	0.051922745
Platform reliability	0.088846289	0.069820768
Platform scalability	0.061162562	0.078987849

Platform security	0.072086251	0.078594689
Platform usability	0.076407563	0.072585278
Standardisation	0.061395405	0.055387329
Supportability (from vendor/provider)	0.071640406	**0.051026439**
Usefulness of visualisation	0.057525871	0.05992999
Variety of data analytics tools/possibilities	0.047339033	0.064390095
Max	0.090967943	0.079113189
Min	0.035686955	0.051026439

Comparison results indicate that a difference in perceiving the importance of criteria exists when comparing the results from IoT vendors in Croatia and Slovenia.

The most important criterion, according to vendors in Slovenia, is platform availability, while vendors in Croatia consider the most important criterion to be device management. The criterion of platform provider quality and reputation has been graded with the lowest weight according to Slovenian vendors, while Croatian vendors graded supportability (from vendor/provider) as the least important.

Interestingly, weight values for Slovenian vendors range from 0.035686955 to 0.090967943, while Croatian vendors graded the criteria with a much lower range [0.051026439–0.079113189].

When comparing the results collected from end users in Croatia and Slovenia, the results show that end users in Slovenia and Croatia share opinions on 75% of the top 30% of calculated values. The calculated values are shown in Table 7.5 and marked as was previously noted.

Also, weight values for Slovenian end users range from 0.049938 to 0.078149, similar to Croatian end users, which range from 0.051725 to 0.079803.

End users from Slovenia and Croatia have a level of agreement of 33% (they agree on five out of 15 criteria). Also, they both graded the criterion of platform functionality as the most important one.

Table 7.5: End users from Croatia and Slovenia

Criteria	**End users SLO**	**End users CRO**
Device management	0.065366	0.073527
Integration flexibility	0.073976	0.064618
Platform availability	0.072052	0.056438
Platform functionalities	**0.078149***	**0.079803***
Platform portability	0.068402	0.075338
Platform price	0.068501	0.066489
Platform provider quality and reputation	0.051097	0.057639
Platform reliability	0.062185	0.065058
Platform scalability	0.076901	0.075378
Platform security	0.077481	0.077991
Platform usability	0.074301	0.071295
Standardisation	0.05718	**0.051725***
Supportability (from vendor/provider)	**0.049938***	0.053536
Usefulness of visualisation	0.060929	0.062425
Variety of data analytics tools/possibilities	0.063541	0.068741
Max	**0.078149***	**0.079803***
Min	**0.049938***	**0.051725***

The calculated weights are graphically represented and shown in Figure 7.3 below. The values are sorted from highest to lowest.

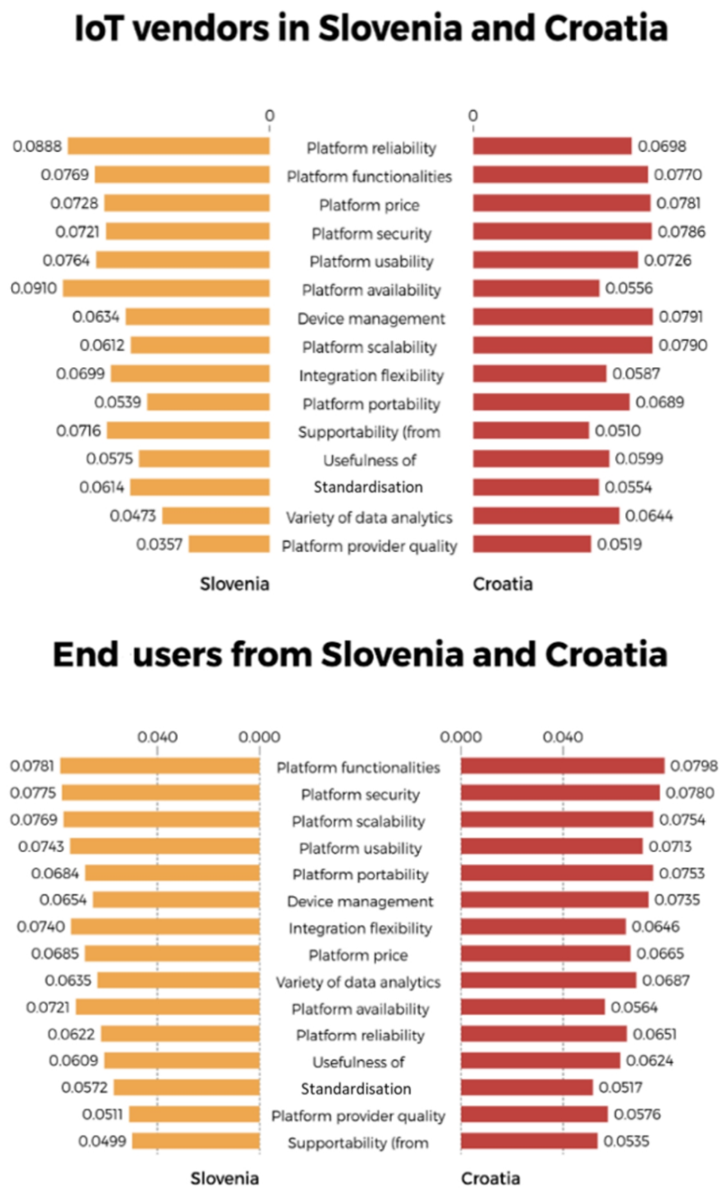

Figure 7.3: Comparison between Slovenian and Croatian experts

To investigate possible discrepancies and agreements on each criterion, another graphical presentation has been created. The graph shown in Figure 7.4 presents this study's main results.

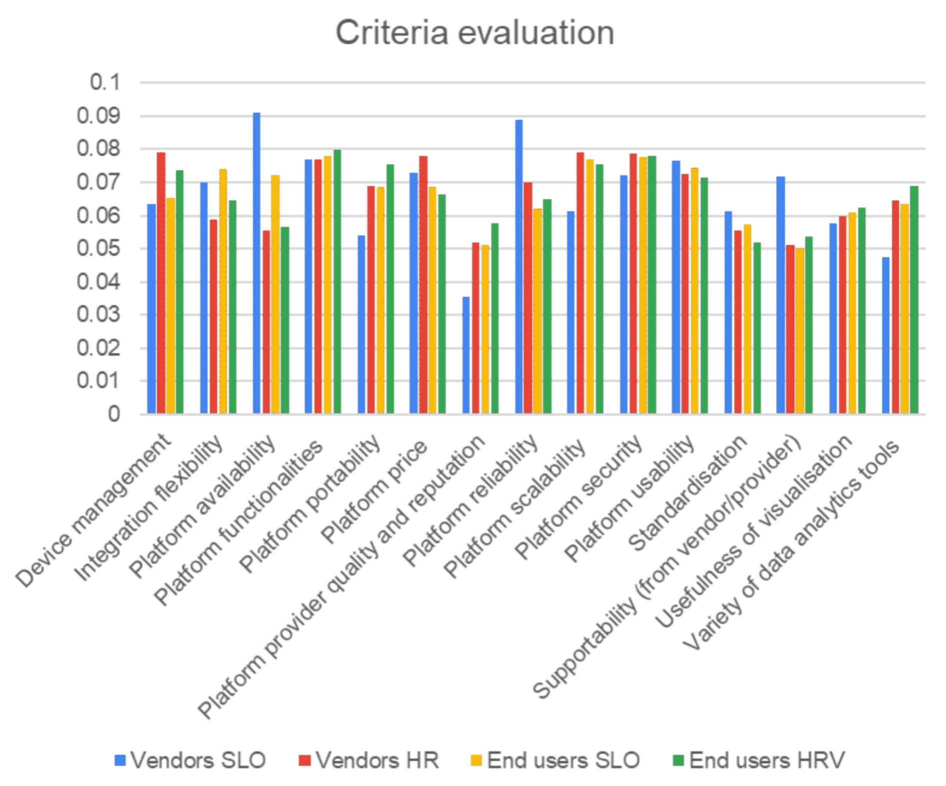

Figure 7.4: Comparison of the evaluated criteria

After calculating and analysing criteria weights for each of the expert groups, it can be concluded that the most similar criteria weights are for (1) platform functionality, (2) platform security, (3) platform usability, (4) standardisation and (5) usefulness of visualisation. Opinions that differ the most are the ones from Slovenian vendors. In addition, platform functionality was graded above 0.7 by each expert.

5. DISCUSSION

The goal of this chapter was initially to examine criteria weights for a selection of IoT platforms according to end users and vendors and compare the results between Croatia and Slovenia. Accordingly, this research helps to answer the question of whether differences exist in the perceived importance of IoT platforms' selection criteria between end users and vendors in Croatia and Slovenia.

It is interesting to point out that results from end users in Croatia and Slovenia are very similar. To be precise, they agree on 75% of the top 20% criteria and the bottommost 20% criteria. End users in Croatia and Slovenia agree on the most important criteria: functionality, scalability and security (each having a weight over 0.7). In addition, they also agree on the least important criteria – standardisation and supportability – unlike vendors who, when comparing the top 20% criteria and the lowest 20%, equally evaluated only one criterion. Both expert groups grade vendors' quality and reputation as the least important criteria (lower than 20%). Even though the reliability of IoT platforms has been highlighted as important (Mashal, Alsaryrah & Chung, 2020), none of the expert groups evaluated it as the most important criterion.

It is also interesting to point out that vendors in Slovenia consider platform availability as the most important, while Croatian vendors believe device management to be the most important criterion. However, when compared to the end users' perspective, it is quite the opposite. Croatian end users consider platform functionality to be the most important criterion.

6. CONCLUSION

This chapter aimed to propose the most important criteria to be considered by relevant end users when selecting the IoT platform within the Smart City concept. Thus, this chapter first identified IoT platform selection criteria based on a literature review. Next, IoT vendors' and smart city managers' (end users') evaluations of the proposed criteria, based on importance, were presented.

Results have been discussed, and similarities, as well as differences, have been pointed out. When ranking the criteria from most to least important, it can be demonstrated that there is a considerable difference between Croatian and Slovenian vendors. A difference also exists between end users, but on a smaller scale. The level of agreement between vendors and end users is graphically presented in Figure 7.5.

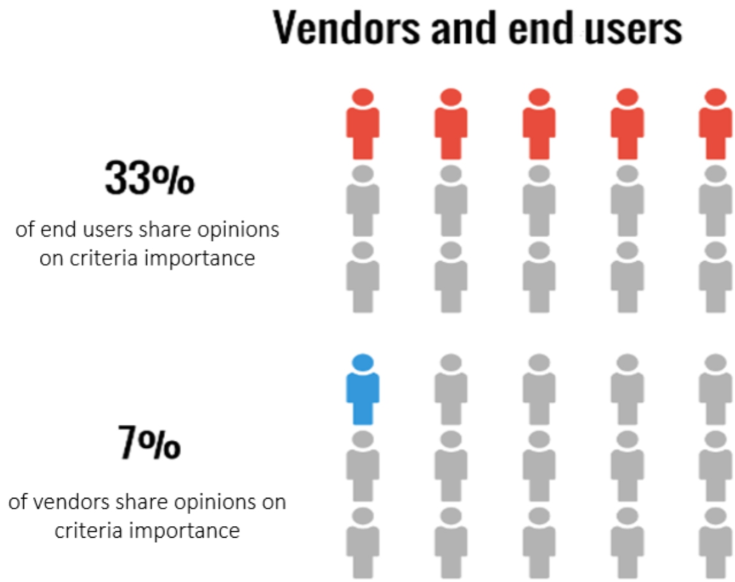

Figure 7.5: Agreement on IoT criteria between Croatian and Slovenian experts

A greater focus should be placed on end users' needs as the user-oriented era becomes more prominent (DeLone & McLean, 2016). The identified similarities between end users in Croatia and Slovenia could serve as implications for vendors when developing IoT platforms. The criterion of functionality, i.e. how IoT platform uses different features to provide the desired outcome, should be the primary focus. Besides functionality, vendors need to focus on scalability, security and usability. These results are particularly important and should be used as a reference point since, for example, scalability is ranked as only 11th (out of 15 criteria) among Slovenian vendors. At the same time, other experts agree on its importance.

To conclude, both vendors and end users can use the results of this study; IoT vendors to better serve the end users' needs when designing future IoT platforms, and smart city administrators, managers and policy planners when selecting IoT platforms for their smart city.

The presented study suffers from a few limitations, which can also serve as starting points for future research. As demonstrated in the results, the evaluated weights that differ the most are the ones from Slovenian vendors. It could be interesting to examine some demographic characteristics of experts to explore whether this impacted received grades. Therefore, it is crucial to study experts' background. The authors used a more generic approach as they could not define the selection criteria for specific cities or specific IoT platforms. In the future, MCDM methods (such as the Analytical Hierarchal Process, the Analytical Network Process, Data Envelopment Analysis (DEA) or PROMETHEE (Barzman et al., 2021) could be used to verify the results and to select the appropriate IoT platform on an actual case study.

Because this study is based on a survey, measuring mistakes such as the number of respondents and the type of questionnaire utilised can occur and therefore present another limitation. Limitations regarding the low number of experts should be addressed by conducting another study with a more significant number of end users. In addition, even though experts could add criteria, none of the additional criteria were identified. In the future, more IoT selection criteria could be inspected but following a multi-level approach, i.e. by devising sub-criteria. For example, a recent study used energy consumption as one of the criteria for smart-object selection (Mashal, Alsaryrah & Chung, 2020). However, this study has not included it, so future research should examine and explore novel criteria to ensure sustainable development of IoT platforms.

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DETERMINANTS OF ACCEPTANCE AND USE OF THE PUBLIC BIKE-SHARING SYSTEM

8

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ABSTRACT

The following chapter empirically tests a model with the goal of determining the factors affecting behavioural intentions for the public bike-sharing system in the city of Split. For that purpose, the Unified Theory of Acceptance and Use of Technology (UTAUT) was applied to inspect performance and effort expectancy, social influence, and facilitating conditions, followed by price value from the UTAUT2 model and expanded with perceived risk, environmental awareness, and physical activity. Of the total number of participants (N = 204) 50% (N = 102) said that they had never used a public bike-sharing system, while the other half (N = 102) claimed to have used it at least once in their lifetime. The results show a statistically non-significant impact of the facilitating conditions on users' behaviour and the impact of perceived risk as well as environmental awareness on the users' intentions. On the other hand, the results confirm a statistically significant influence of performance and effort expectancy, social influence, price value as well as physical activity on behavioural intention toward using the public bike-sharing system.

Keywords: behavioural intentions, public bike-sharing system, UTAUT, UTAUT2

1. INTRODUCTION

Building an efficient and sustainable transport system is one of the biggest and most important challenges of the urban way of life. Urban centres are considered the main focal points of social and economic activities (Cheba & Saniuk, 2016), and the problem of transport is often manifested in traffic jams and congestion. According to the UN (2020), the total number of people living in cities was approximately 4.4 billion in 2020, and, by 2050, 6.7 billion people are expected to live in urban areas. According to Ghate and Sundar (2013), the constant population growth in limited urban spaces also causes a significant increase in passenger cars and is thus a major sustainability and environmental issue (Gwilliam et al., 2004). Through the concept of smart cities, various models of urban transport are being developed to facilitate decision making regarding the conceptual and logical transport structure and the adaptation of urban infrastructure to new requirements. According to Gonzalez-Feliu (2018), a unique model for sustainable transport is unrealistic for two reasons: the interpretation of the term "sustainable development" varies considerably among researchers, and the methods and research approaches also differ, leading to different research results. But it is the concept of sustainable development – which focuses on social acceptability, environmental feasibility and economic viability – that successfully steers urban development toward smart solutions and sustainable development (Goldman & Gorham, 2006).

The dynamic growth of the motor industry is considered the greatest socio-economic transformation of the 20th century. Every family owns at least one personal vehicle, causing a major turnaround in economic activities, individuals' daily transportation options, retail structure and various ways of accessing education and health needs (Urry, 2008). But, in addition to these great strides in improving living standards, there are different negative consequences of mass use: congestion, collisions, declining air quality, social exclusion and reduced physical activity, leading to a reduction in general health and an increase in obesity (Docherty et al., 2018). Kampf et al. (2010) state that it is necessary to reduce the use of motor vehicles to a sustainable level (with the expansion of public passenger transport systems being a basic prerequisite for achieving this goal) and to plan integrated transport systems that create new transport options. Such an integrated system should take into account the various needs of all components of that system, which may be the needs of the infrastructure, organisation or information system – pedestrians need a crosswalk, cyclists need the infrastructure of bike lanes, motor vehicles need a road and a traffic control system, etc.

The research on smart mobility implementation in Croatia, conducted in 128 cities (Brčić et al., 2018), found that smart concepts, including smart mobility, are increasingly being implemented in cities. The three main components of smart mobility that are being implemented in Croatian cities are ICT technologies (85.2% of cities), smart public transport (65.5% of cities) and smart parking (58.6% of cities). Cities in which smart mobility development is recognised also have a much higher level of smart urban development than other cities, which leads to the conclusion that smart mobility is a crucial part of smart cities. The notion of smart mobility emerges as a response to accumulated socio-economic problems and is described as a transition of equal reach and importance as motor mobility, where the focus is on making positive changes without compromising transport needs. In other words, without losing the possibility of access to mobility at any time, the transition to green, clean, efficient and flexible transport is increasingly considered necessary for sustainable development. This smart transition to sustainable transport brings great security benefits and anticipated lower costs to users due to increased resource efficiency of mobility systems (Docherty et al., 2018). Smart mobility, as an important component of a smart city, aims to raise operational efficiency, share information and improve the quality of services and living standards (Brčić et al., 2018). Smart mobility contributes to this concept by optimising travel time; freeing up space; improving economic, environmental and weather costs; reducing emissions and reducing traffic congestion. Although smart mobility leads to a cost reduction for users, which can lead to the solution of long-term problems, the transition to a smart mobility system does not happen simultaneously or at the same speed in all areas and regions. Namely, the implementation of smart mobility solutions is predominantly in urban centres, which creates a big difference in the rules of modelling and regulation of urban, semiurban and rural areas.

Additionally, problems and their solutions take place at the state level. One smart transport model is the bicycle-sharing system, which is a green solution to the problem of urban mobility. Bicycle-sharing systems are public bike-sharing systems that use the Internet of Things (IoT) technology. IoT refers to the networking of "smart things", which can share information, data and resources, respond to and act in various situations and react to environmental changes (Madakam et al., 2015). In this way, citizens are given an alternative, green opportunity to use public transport, with a simple and cheap system of picking up and returning bicycles.

2. PUBLIC BIKE-SHARING SYSTEMS

By integrating information and communication technology (ICT) into everyday lives, simple activities, such as cycling, fall under the influence of ICT (Ilhan & Fietkiewicz, 2017). Bicycles offer a good alternative for short-distance mobility. According to Kampf et al. (2010), bicycles reach an average speed of 15–25 km/h in urban areas and are considered a potential alternative to cars for distances up to 8 km. In addition, the survey states that, on average, 3/4 of Europeans view the bicycle very positively compared to the car in the city. As a need for an alternative, green type of mobility, public bicycle-sharing systems are being developed in large urban areas, and these systems are seen as a step towards sustainable urban development. However, such systems require high levels of information flow to be functional; information such as where to pick up the bicycle, how to return it, how to pay, etc. It is necessary for users to start using such systems. Matrai and Toth (2016) cite four generations of public bicycle-sharing systems (PBSSs), with the first system established in Amsterdam in the 1960s. The first generation of the PBSS was based on providing free bicycles that users would borrow and return. The first generation did not have organised locations for picking up and returning bicycles and, since the service was free, users had no reason to return bicycles in good condition. Eventually, due to vandalism, these systems were soon shut down (Midgley, 2011). In the 1990s the second PBSS generation was launched in Denmark, and it was characterised by custom bicycles and fixed stations. However, it was still free for use. The third generation was established in Copenhagen under the name Bycyklen and is considered the first high-scale scheme to be integrated with ICT. In this generation, access with a user card was introduced for the first time at fixed stations that operated through affiliation programmes or annual billing. The last, fourth generation is the generation of PBSS used today. The main features of this generation are access to mobile devices (via user applications and registration systems), free use within a certain time frame, providing real-time feedback, use of RFID technology to identify and view bicycle locations and high-level integration with various systems. These components were already integrated within the third generation of the PBSS. The features that set the fourth generation apart are mobile bicycle pick-up/drop-off stations, solar panels to collect energy needed to operate the stations, electric bicycles and mobile applications. Furthermore, Midgley (2011) states that 213 different PBSSs were reported in 2008, almost all of which operated in Europe. Chen et al. (2018) recently introduced the fifth generation referring to systems with bicycles without stations and great data management capabilities.

Various favourable factors have caused a dynamic growth in the popularity of public bicycle sharing. For example, Munkacsy and Monzon (2017) state that the reason for the rapid growth of the PBS system is its environmental friendliness, low cost, efficiency for short distances and as an intermodal tool. Ilhan and Fietkiewicz (2017) list several PBSSs worldwide: YouBike, BiciMAD, Viu BiCiNg, Nextbike, Ofo, Mobike, Forever BIXI, Santander Cycles, The Vélib, Citi Bike, O'Bike and Q Bike.

3. THE CASE OF NEXTBIKE IN THE CITY OF SPLIT

The Nextbike smart mobility solution has been implemented in more than 300 cities worldwide, including Croatia (Vlastos et al., 2014). While there are other PBSSs in European countries (such as EasyBike, Bixi, Call a Bike, Bicimad), the Nextbike project is the most famous and commonly used PBSS in Europe. Matrai and Toth (2020) state Nextbike as a classic example of an organisation that operates as both owner and provider; in other words, Nextbike provides and maintains bicycles and manages the entire system. A significant advantage of this prevalence is the ability to log in to any city where Nextbike is implemented. Nextbike is considered the largest PBSS in the region. The project has been implemented in about 20 Croatian cities, and, in 2019, this project was introduced in Split. Currently, there are 80,000 users registered in Croatia, of which more than 24,000 are registered in Split (Nextbike, Milanović, 2021).

Furthermore, there are currently about 300 bicycles in Split as part of the Nextbike project, of which 182 electric bicycles are deployed at 41 stations. An interview conducted with Nextbike Split staff revealed that the plan is to expand the number of bicycles, stations and racks to bring even more citizens closer to using this form of transport. Eighty per cent (80%) of total users are locals who have recognised cycling as a great green alternative to public transportation. It has previously been stated that cyclists reach an average speed of 15–25km/h, which is considered a good alternative solution for passenger cars for distances up to 8 km (Kampf et al., 2010). Considering that their use is free for the first 30 minutes, it is more than enough for public transport since the area of Split covers about 80 km2. Another significant advantage of PBSSs over using private transportation is that it solves the problem of finding parking spaces, which are particularly scarce during the summer season.

The bicycle rental has three steps. The first step is user subscription, which begins with registration via a mobile application, customer support centre, at Nextbike stations or on their website. Upon registration, the user enters a plan for using the system, and once the account is created, they can use Nextbike systems worldwide. Payment can be made by credit/debit card, SMS message or bank transfer. Registration cannot be done without submitting a photo of one's ID, which is used for identity confirmation, protection against vandalism and confirming that the user is old enough to use the system. After the registration process is finished, the user receives a confirmation e-mail. The second step is to rent a bicycle, which can be done in several ways:

- The first way is to use a mobile application, and it assumes entering the bicycle number and the security pin.
- Another way is to use a station, in which case the user needs to select the rental on the touch screen, enter their mobile phone number and registration pin, as well as the bicycle number.
- The third way is to scan the bike's QR code, which automatically registers the rental in the system.
- It is possible to rent a bike by calling a phone number

After choosing one of the rental methods, the user takes the bicycle and starts riding. At the end of the ride, the bicycle needs to be returned to a station, which is done by pushing the bicycle into a lock, which locks automatically. If the bicycle is returned correctly, the station emits an acknowledgment sound signal, and the status that the bicycle has been returned is displayed in the user's mobile application. It is also possible to temporarily park the bicycle using the “Park and continue renting” function within the mobile app. In case all the racks are occupied, the bicycle must be locked manually with a mechanical padlock to the station stand. An additional option when using Nextbike systems is creating a Nextbike card, which simplifies the entire process of renting a bicycle (the cost of a card is 20 kn). The Nextbike system also provides a smart fault-tracking solution that deactivates bicycles after a report or automatic fault detection so they cannot be rented.

All these aspects of the smart solution of the Nextbike system are supported by a network of applied technologies that make the whole system work. For example, setting up the station is meaningless without networking and setting security measures, bicycles without tracking methods cannot be numbered and tracked, and parking bicycles would not be possible without the supporting technology of bicycle registration. The administration of the entire Nextbike system takes place via the Nextbike cloud Office software. It is a complete CRM system for administering user processes, but it doubles as a remote diagnostic tool for efficient management of bicycle fleets and stations.

A location map of Nextbike stations in Split is shown in Figure 8.1.

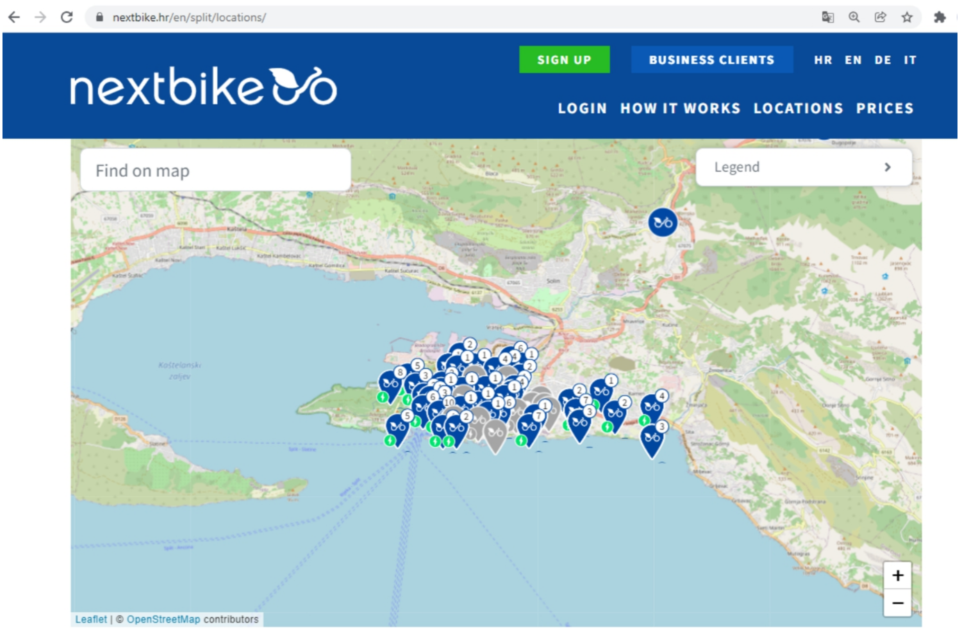

Figure 8.1 : Nextbike map with the locations of all stations in Split

All Nextbike stations in Split have a SIM card, and some stations are connected by an optical network. The SIM card (subscriber identity module) is considered a method of specific security cryptography of device security, and this cryptographed algorithm is extremely difficult to hack (Pang et al., 2013). A SIM card is a module that contains and encrypts information when sent to the main system. When all information from both sender and receiver is confirmed, the message can be decrypted. In this way, communication between the terminal and the main system occurs in a secure, encrypted way. A solar panel is connected to each terminal, which is sufficient for the self-sustaining power supply of the station. The terminals are equipped with a touch screen and an RFID reader.

However, in an interview with the staff of Nextbike Split, it was stated that an optical network connects some locations. In addition, there are cameras at all locations that are connected to the Split parking control centre (via optical networking). According to Ji and Wang (2016), optical networking is a key contributor to IoT networks and communications, emphasising fiber optic technologies.

IoT technology is also integrated into each bicycle, which differentiates several types of bicycles: classic bicycles, classic ecobicycles, smart bicycles and e-smart bicycles (Nextbike, 2016). The classic bicycle contains an adapter with an RFID chip for docking and communication with smart stations. The station recognises the bike's chip using RFID radio waves and automatically registers a bicycle's pick-up/return. It then passes this information to the system, and the user can view the bicycle status in the Nextbike application. The redesign of the classic bicycle into a classic ecobicycle refers to replacing ecologically nonrenewable bicycle parts with eco-renewable ones. Smart bicycles are based on the classic bicycle model combined with smart electric computer components and unique locking technology. The bicycle has an integrated electro-mechanical locking system, and the electric computer has integrated GPS and GSM communication modules for monitoring the geolocation of the bicycle. Additionally, an NFC reader provides internal data storage, and the computer controls the locking mechanisms of the bicycle. E-smart bicycles are electric bicycles made based on a smart bicycle containing a rechargeable motor, which is charged at the stations.

Another smart characteristic of the Nextbike system is the mobile application. According to Nextbike, in some cities, more than 80% of bookings are made via the mobile application thanks to the integration of smart technologies. Easy access to bicycles is provided by scanning the QR code on bicycles or by NFC scanning. In this way, it is not necessary to enter additional data (a PIN, username, etc.). The application provides additional features, such as access to maps with the stations' locations, the locations of available bicycles, driving history, account information and the possibility of reporting bicycles damage.

4. CONCEPTUAL GROUNDING AND HYPOTHESES DEVELOPMENT

The Unified Theory of Acceptance and Use of Technology (UTAUT) is one of the most popular theories applied in various research to examine the behavioural intention and real-use behaviour of specific technology users. Venkatesh et al. (2003) presented the UTAUT model as a result of a combination of eight different theories: the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivational Model (MM), the Theory of Planned Behaviour (TPB), the Combined Theory of Planned Behaviour/Technology Acceptance Model (C-TPB-TAM), the Model of PC Utilisation (MPCU), the Innovation Diffusion Theory (IDT) and the Social Cognitive Theory (SCT). TAM stands out as the model closest to UTAUT, since both models suggest that technology use is influenced by behavioural intention to use technology (Shachak et al., 2019). The UTAUT model has been extended into the UTAUT2 model with additional predictors: hedonic motivation, price value and habit.

This study empirically tested a model to predict the factors affecting users' behavioural intentions to use the PBSS in the city of Split. Along with behavioural intention and use behaviour, the variables of performance expectancy, effort expectancy, social influence and facilitating conditions from UTAUT were included in the research model. Furthermore, the price value variable was taken from UTAUT2, and the model was additionally extended by including perceived risk, environmental awareness and physical activity.

Performance expectancy (Dwivedi et al., 2011) is defined as the level to which individuals believe that the use of new technology will improve their performance. Users will be more motivated to use new technologies if they believe that implementing this technology will positively impact their everyday lives. Because Nextbike Split provides a solution to the problems of congestion, emission and parking, the assumption is that performance expectancy will positively affect the behavioural intention to use the Nextbike system (H1).

Effort expectancy refers to the level of simplicity tied with the use of the system. Regardless of how good the system is as a solution to the problem, its applicability completely fails if users cannot learn to use it. According to Alalwan et al. (2017), an individual's intention to use a system is predicted not only by the positive features of the system but also by the level of ease of use. In other words, as the effort required to get used to and learn a new system rises, the users are less likely to actually use the system. The hypothesis is that the effort expectancy will positively affect the behavioural intention to use the Nextbike system (H2).

Social influence refers to an individual's perception of others' opinions about whether or not they should use new technology (Venkatesh et al., 2003). Social influence can come from various sources, such as family, reference groups, friends, colleagues, etc. (Alawan et al., 2017). Therefore, if the social impact of an individual's environment on the new technology is negative, the individual's opinion will lean towards the negative side. On the other hand, if the social influence is positive, it is more likely that social impact will positively affect behavioural intention to use the Nextbike system (H3).

According to Venkatesh et al. (2003), facilitating conditions refer to how an individual believes that an organisational and technical infrastructure exists to support the use of the system. Therefore, the assumption is that the facilitating conditions will positively affect the use (behaviour) of the Nextbike system (H4).

Price value (Dwivedi et al., 2011) refers to the user's perceived value for money. If the user perceives that the value of using the technology is favourable, i.e. that the use is profitable, they are more likely to use it. In case the user thinks that the use of the service is more expensive than it should be, aversion to the use of the technology will increase. Therefore, the price value will positively affect behavioural intention to use the Nextbike system (H5).

Perceived risk is related to users that sense any likely losses that could arise as a result of the uncertainties of utilising technology, while the anticipated losses may involve any unfavourable results to end users, such as financial losses, a violation of privacy, psychological concern, waiting time, etc. (Kofi Penney et al., 2021). It is hypothesised that the perceived risk will positively affect behavioural intention to use the Nextbike system (H6).

Environmental awareness refers to the environmental effects of using a public bicycle-sharing system on the environment, as opposed to alternative opportunities for public and private mobility. So, the assumption is that environmental awareness will positively affect behavioural intention to use the Nextbike system (H7).

Furthermore, cycling also requires some level of physical activity, which also directly impacts health. For that reason, it is assumed that physical activity will positively affect behavioural intention to use the Nextbike system (H8).

While the constructs of performance expectancy, effort expectancy, social influence, price value, perceived risk, environmental awareness and physical activity are the main predictors of behavioural intention with regards to the use of a particular technology, this same behavioural intention and its facilitating conditions affect use behaviour. More specifically, the behavioural intention (which refers to the user's overall attitude towards technology) will positively affect the user's behaviour (H9).

5. DATA AND METHODS

5.1. Research instrument

The main constructs of the questionnaire were performance expectancy, effort expectancy, social influence, facilitating conditions, price value, perceived risk, environmental awareness, physical activity and behavioural intention. The questionnaire consists of 30 items measured by the Likert scale from 1 ("I completely disagree") to 7 ("I completely agree"). A total of 239 questionnaires was collected, of which 35 respondents partially completed the questionnaire and were rejected for further analysis. Therefore, the total number of questionnaires in the analysis was 204. The questionnaire was created using the LimeSurvey tool and conducted online. Responses to the questionnaire were collected over two months, in July and August 2021, by sending questionnaires directly to respondents and with the help of the Nextbike staff.

5.2. Participant demographics

Out of a total of 204 respondents, 94 (46%) are aged 25–34, 56 respondents (27%) are aged 35–44 and 43 (21%) are aged 18–24. Of the other age groups, 9 respondents (4%) answered that they belong to the 45–60 age group, while one person (0.49%) is in the 60+ age group. The majority of respondents are male (67%), compared to 33%, who are female. A total of 110 respondents (53%)

owned a car. On the other hand, owning a bicycle is much more polarising, whereas 44 respondents (22%) own a bicycle. Usage experience refers to the user's frequency of use of the Nextbike system. Of the 204 respondents, 102 (50%) answered that they never use the Nextbike system, while 50% had used the system at least once. Of these, 38 (19%) use the system once a month, 30 respondents (15%) use the system once a week, 27 respondents (13%) use the system several times a week, and 7 respondents (3%) use Nextbike daily.

5.3. Data analysis methods

For defining the variable structure of the proposed research model, factor analysis was applied (Hair et al., 2010). Only items whose difference in factor cross-loadings was 0.2 or greater and for which the factor loading was at least 0.4 were kept. The minimal sample size has been achieved (200+), and the ratio of participants and variables is satisfactory (Hair et al., 2010). To check internal consistency, Cronbach's alpha coefficient was calculated (Cronbach, 1951). In addition, regression analysis was used to determine the relative contribution (independent relationship) for each explanatory variable by controlling for the effects of other explanatory variables.

6. RESULTS

Although values for skewness and kurtosis between -2 and +2 are considered acceptable to prove a normal distribution (George & Mallery, 2010), other lower, acceptable ranges for skewness and kurtosis below +1.5 and above -1.5 (Tabachnick & Fidell, 2013) have been advocated to consider the distributions to be normal. The mean does not vary significantly and ranges from 3.33 to 5.08 for the items on a scale of 1 to 7. Only one item (usage behaviour) has a mean of 2.01, but this item is measured on a scale of 1 to 5. All distributions are normal, i.e. they meet the criterion of skewness or kurtosis below +1.5 and above -1.5. Descriptive statistics are calculated and presented in Table 8.1.

Table 8.1: Descriptive statistics

Construct	Item	N	Min	Max	Mean	Std. Dev.	Skewness	Kurtosis
Performance expectancy UTAUT	PE1	204	1	7	4.07	1.805	-.149	-1.089
	PE2	204	1	7	4.09	1.976	-.162	-1.261
	PE3	204	1	7	4.26	1.965	-.190	-1.167
	PE4	204	1	7	4.18	1.945	-.100	-1.132
Effort expectancy UTAUT	EE1	204	1	7	4.61	1.774	-.418	-.909
	EE2	204	1	7	4.62	1.809	-.399	-.898
	EE3	204	1	7	4.68	1.841	-.369	-.917
	EE4	204	1	7	4.67	1.821	-.413	-.803
Social influence UTAUT	SI1	204	1	7	4.23	1.354	-.150	-.025
	SI2	204	1	7	4.28	1.491	-.075	-.333
	SI3	204	1	7	4.24	1.511	-.025	-.325
Facilitating conditions UTAUT	FC1	204	1	6	3.77	1.495	-.234	-.834
	FC2	204	1	7	4.69	1.702	-.390	-.793
	FC3	204	1	7	4.56	1.779	-.233	-1.106
	FC4	204	1	7	4.71	1.681	-.170	-1.000
Price value UTAUT2	PV1	204	1	7	4.88	1.534	-.519	-.484
	PV2	204	1	7	5.03	1.567	-.631	-.434
	PV3	204	1	7	5.03	1.580	-.564	-.563
Perceived risk	PR1	204	1	7	3.42	1.286	.264	-.269
	PR2	204	1	7	3.51	1.218	-.130	.148
	PR3	204	1	7	3.33	1.423	.057	-.414
Environmental awareness	EA1	204	1	6	4.97	.931	-1.015	1.499
	EA2	204	1	6	4.99	.893	-.886	1.544
Physical activity	PA1	204	1	7	5.08	1.389	-.396	-.504
	PA2	204	1	7	4.76	1.529	-.248	-.759
	PA3	204	1	7	4.70	1.602	-.235	-.777
Behavioural intention UTAUT	BI1	204	1	7	4.02	1.940	-.085	-1.341
	BI2	204	1	7	3.37	2.065	.359	-1.256
	BI3	204	1	7	4.48	1.946	-.292	-1.196
	BI4	204	1	7	4.52	1.903	-.307	-1.145
Use behaviour (UTAUT)	USE	204	1	5	2.01	1.222	.872	-.512
Valid N (list wise)		204						

Principal component analysis was performed with the 30 variables. Since the number of respondents was N=204, the ratio of the number of respondents and variables met the criterion of 5:1 (Hair et al., 2010). The KMO test (0.917) confirms the adequacy of the sample, the tested model fits the data and Bartlett's test for sphericity is statistically significant. The factor structure was set at eight components, and only items of those scales whose influence on behavioural intention and use behaviour was assumed in the hypothesized model were analysed. Factor analysis was performed without behavioural intention (items are not adequately projected on the corresponding factor) and without behaviour (only one was item analysed). Results are shown in Table 8.2.

Table 8.2: Total variance explained for the factor structure

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumul-ative %	Total	% of Variance	Cumul-ative %	Total	% of Variance	Cumul-ative %
1	13.522	52.007	52.007	13.522	52.007	52.007	4.176	16.063	16.063
2	2.478	9.531	61.538	2.478	9.531	61.538	3.076	11.831	27.894
3	1.871	7.195	68.733	1.871	7.195	68.733	3.075	11.828	39.722
4	1.380	5.307	74.040	1.380	5.307	74.040	3.073	11.819	51.542
5	1.120	4.308	78.348	1.120	4.308	78.348	2.812	10.817	62.358
6	1.091	4.197	82.545	1.091	4.197	82.545	2.597	9.988	72.346
7	.950	3.655	86.200	.950	3.655	86.200	2.423	9.321	81.667
8	.784	3.015	89.215	.784	3.015	89.215	1.962	7.547	89.215
Extraction Method: Principal Component Analysis.									

Table 8.3: Rotated Component Matrix

	Component							
	1	2	3	4	5	6	7	8
PE3 Using a bike-sharing system helps me to complete tasks faster.	.847							
PE2 Using the bike-sharing system increases the chances of me achieving the tasks that are important to me.	.839							
PE4 Using a bike-sharing system raises my productivity.	.834							
PE1 I find the bike-sharing system useful in my daily life.	.764							
SI2 People who influence my behaviour think that I should use a bike-sharing system.		.865						
SI3 People whose opinions I value prefer to use the bike-sharing system.		.859						
SI1 People who matter to me think I should use a bike-sharing system.		.815						
FC1 I have the resources needed to use the bike-sharing system.			.830					
FC2 I have the knowledge needed to use the bike-sharing system.			.756					
FC4 I can get help from others when I have difficulty using the bike-sharing system.			.675					
FC3 The bike-sharing system is compatible with other technologies I use.			.659					
PV1 The bike-sharing system has a reasonable price.				.865				

PV2 The bike-sharing system provides good value for money.				.842				
PV3 At the current price. the bike-sharing system provides good value.				.830				
EE4 It's easy for me to become proficient in using a bike-sharing system.					.730			
EE2 My interaction with the bike-sharing system is clear and understandable.	.412				.715			
EE3 I find the bike-sharing system easy to use.					.691			
EE1 It's easy for me to learn to use the bike-sharing system.					.687			
PA3 I want to use a bike-sharing system because of the physical activity it provides me.						.824		
PA2 I find that the bike-sharing system provides me with adequate physical activity.						.823		
PA1 Using a bike-sharing system is good for my health.						.680		
PR2 Using a bike-sharing system puts me at risk.							.928	
PR1 I find that using the bike-sharing system threatens my privacy.							.913	
PR3 Using a bike-sharing system will not fit well into my image.							.774	
EA2 I believe that the bike-sharing transport system is more sustainable than other transport systems.								.878

EA1 By using the bike-sharing system, I have a positive impact on the environment.								.875
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.								
a. Rotation converged in 6 iterations.								

The calculated Cronbach alpha of extracted factors were PE=0.965, EE=0.972, SI=0.950, FC=0.937, PV=0.979, PR=0.851, EA=0.877, PA=0.897, Initial construct BI=0.950. According to the previously presented hypothetical model, the analysis is divided into two regression models: the first model measures the impact of observed predictors on behavioural intention, while the second refers to measuring the impact of behavioural intention and facilitating conditions on use behaviour. The model tested if the extracted factors can significantly predict the behavioural intention. The results, including the level of statistical significance, the standardised Beta coefficient, R, and R-squared, are presented in Table 8.4. The R-value of 0.903 is quite high, where the minimum value for further analysis is 0.4 (Jain & Chetty, 2019). The R2 value refers to the total variation of the dependent variable that can be explained by the independent variables. The minimum required variance value should be 0.5, and the R2 value of the model satisfies this condition.

Furthermore, an ANOVA test was performed, which shows whether the significance of the model is high enough to estimate the model's output. The significance of the model should be less than 0.05 for the variable to be considered significant. In this model, the significance level is <0.01, which means that the model is significant.

Table 8.4: Enter linear regression for dependent variable behavioural intention

Coefficients						
		Unstandardised Coefficients		Standardised Coefficients		
Model		B	Std. Error	Beta	t	Sig.
Enter linear regression R=0.903 R Square=0.815	(Constant)	-1.657	.409		-4.049	.000
	PE	.269	.049	.269	5.444	.000
	EE	.191	.059	.181	3.221	.001
	SI	.276	.055	.209	5.019	.000
	PV	.181	.053	.151	3.426	.001
	PR	-.097	.051	-.061	-1.880	.062
	EA	.067	.078	.032	.869	.386
	PA	.345	.057	.259	6.073	.000
a. Dependent Variable: BI						

It is evident that the variables PR (perceived risk) and EA (environmental awareness) have a significance higher than 0.05 (values 0.062 and 0.386). Therefore, it was concluded that the PR and EA variables do not significantly impact behavioural intention. Using the Stepwise method of entering data into the regression model, variables that were not statistically significant were omitted. The previously mentioned F value, which should be between 0.5 and 1, was used as a criterion for data entry. By adding independent variables to the model, the values of R and R2 increase. In other words, model 5 shown in Table 8.4, which includes all statistically significant constructs, best describes the variation of the dependent variable BI.

Table 8.5: Stepwise linear regression in the fifth step for dependent variable behavioural intention

Coefficients						
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
Stepwise linear regression R=0.900 R Square=0.811	(Constant)	-1.822	.242		-7.515	.000
	EE	.204	.059	.194	3.462	.001
	PA	.350	.054	.263	6.446	.000
	PE	.270	.050	.270	5.435	.000
	SI	.263	.055	.199	4.781	.000
	PV	.207	.051	.173	4.054	.000
a. Dependent Variable: BI						

It can be concluded that five constructs (effort expectancy, physical activity, performance expectancy, social influence and price value) have a significant impact on behavioural intention. However, the variables of perceived risk and environmental awareness are not statistically significant predictors of behavioural intention. Since the results of stepwise linear regression coincide with the results of enter linear regression, the interpretation of only the enter linear regression model will be presented below.

The performance expectancy has a significant and positive impact on the behavioural intention to use the Nextbike system, confirming hypothesis H1 (significance level <.001 and a standardised beta coefficient of 0.269). The effort expectancy with a significance level of 0.001 and a standardised beta coefficient of 0.181 positively affects the behavioural intention to use the Nextbike system by users, which confirms hypothesis H2. The social influence has a significance level of <.001 and a beta coefficient of 0.209. Therefore, it also has a statistically significant and positive impact on the intended use, as evidenced by the H3 hypothesis. The price value with a significance level of 0.001 and a standardised beta coefficient of 0.151 has a significant and positive impact on the intended use of the Nextbike system, which confirms hypothesis H5. A construct that does not reach the required level of significance is perceived risk, which indicates a predominantly negative user perception.

Although the significance of perceived risk is 0.062 and it is not considered a statistically significant influence on the purpose of the behaviour, its impact is negative with a standardised beta coefficient of -0.061 Therefore, hypothesis H6 cannot be accepted. Another statistically negligible construct is environmental awareness. The level of significance of this construct is 0.386, and the standardised beta coefficient is 0.032. In both cases, the structure of the answers to the questions is extremely polarising, with over 90% of respondents expressing a level of agreement with the claims. Therefore, environmental awareness has an extremely small impact on the intended use of users, and hypothesis H7 is also rejected. Finally, physical activity also positively affects behavioural intention with a significance level of <.001 and a standardised beta coefficient of 0.259, confirming the H8 hypothesis.

The second model tests the effects of the facilitating conditions and behavioural intention on use behaviour. Usage was examined by asking the question "How often do you use the Nextbike system?"

Table 8.6: Stepwise linear regression in the fifth step for dependent variable behavioural intention

Coefficients[a]						
		Unstandardised Coefficients		Standardised Coefficients		
Model		B	Std. Error	Beta	t	Sig.
Enter linear regression R=0.702 R Square=0.493	(Constant)	.000	.188		-.001	.999
	FC	.055	.062	.069	.886	.377
	BI	.432	.052	.648	8.297	.000
a. Dependent Variable: How often do you use the Nextbike system?						

The R-value is 0.702, which satisfies the condition of the value being greater than 0.4. However, the R2 value does not meet the condition that the value should be greater than 0.5. This means that the model is not very effective in predicting the relationships between independent and dependent variables, although a value of 0.493 is relatively close to a satisfactory level. The facilitating conditions do not have a significant impact on the use of technology, with a beta coefficient of 0.069 and a significance level of 0.377, thus rejecting hypothesis H4. Therefore, the facilitating conditions construct has been dropped from the model, and behavioural intention remains the only factor that has a significant impact on the use of technology, which confirms hypothesis H9.

7. CONCLUSION

The research results show a significant and positive relationship between effort expectancy, physical activity, performance expectancy, social influence, as well as price value and behavioural intention to use the Nextbike system. Also, the relationship between behavioural intention to use and actual use of the Nextbike system is significant and positive. Since its inception in the 1960s, PBSSs have been transformed into highly standardised and technologically equipped systems that compete with standard public transportation systems. The Nextbike project was implemented in Split in 2019; today, it has more than 24,000 registered users and includes 300 bicycles deployed at 41 stations. Although cycling in the city of Split is quite underdeveloped and new, this project has been successfully implemented and accepted by a large number of residents. Using data transfer technologies attached to the concept of the IoT, Nextbike Split belongs to the category of smart and sustainable solutions. Furthermore, a sustainable concept should have a high impact on the formulation of urban development policies and strategies and promote constant economic as well as social progress. This research certainly contributes to raising awareness and identifying the dominant factors influencing the intention to use this type of green and sustainable transport.

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REVIEWER COMMENTS

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The book offers a lot and gives the audience an understanding of the main issues in developing and implementing smart cities. It provides a valuable equilibrated combination of relevant concepts and technologies included in smart cities and practical perspectives on how innovative processes and services are perceived at regional levels (in cities in Croatia and Slovenia). Synthesising the main features and challenges of the Smart City, the clear and coherent content of this collective manuscript succeeds in achieving the goal stated by the editors, i.e. contributing to the understanding of emerging digital technologies, their impact and applicability in cities. Through a multidisciplinary approach, the book clarifies the main problems involved in implementing technologies and smart city governance and highlights future research directions. The content's quality and degree of synthesis are demonstrated by the extensive valuable selection of references on which each chapter is based. In conclusion, I am convinced that this publication will give the audience the key to understanding the significant transformation of future living and working environments and allow future professionals to operate smoothly and smartly.

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This book represents the synthesis and systematisation of recent and relevant research on smart cities from both theoretical and practical perspectives and, as such, significantly adds to the extant body of knowledge. It provides implications for both researchers and practitioners. Scholars can use it as a background for future advances in the field, while government organisations, managers, policymakers, and strategic planners can employ it as a reference and a set of guidelines in all stages of the city transition into the smart mode of operating. Considering the comprehensiveness of topics covered in this book, it meets the learning outcomes of university courses related to smart city ecosystems and can therefore serve as a university textbook in such courses.

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