UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

OPEN DATA AS A FOUNDATION FOR THE DEVELOPMENT AND INNOVATION OF SMART CITY SERVICES IN THE MUNICIPALITY OF LJUBLJANA

Ljubljana, October 2025 NEDA JEVTIĆ

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ABSTRACT

The master's thesis aims to explore how open data utilization can improve smart city services and increase innovation in the Municipality of Ljubljana. It combines theoretical insights on smart cities, service innovation, value of open data in smart cities, together with interviews with professionals from the Office for Digitalization in the Municipality of Ljubljana. Challenges such as privacy restrictions and governance complexity impose barriers to more efficient and widespread open data utilization within the municipality and broader. This thesis concludes that opportunities for further development lie in improved data governance, cross-sector collaboration and the European data space for smart communities.

KEY WORDS: smart cities, open data, service innovation and development, citizen and stakeholder engagement, open data portals

SUSTAINABLE DEVELOPMENT GOALS

POVZETEK

Magistrsko delo raziskuje, kako lahko uporaba odprtih podatkov izboljša storitve pametnega mesta in poveča inovativnost v Mestni občini Ljubljana. Združuje teoretične ugotovitve o pametnih mestih, inovativnosti storitev, vrednosti odprtih podatkov v pametnih mestih ter intervjuje s strokovnjaki iz Službe za digitalizacijo Mestne občine Ljubljana. Izzivi, kot so omejitve zasebnosti in kompleksnost upravljanja, predstavljajo ovire za učinkovitejšo in širšo uporabo odprtih podatkov v občini in širše. Magistrsko delo ugotavlja, da priložnosti za nadaljnji razvoj ležijo v izboljšanem upravljanju podatkov, medsektorskem sodelovanju in evropskem podatkovnem prostoru za pametne skupnosti.

KLJUČNE BESEDE: pametna mesta, odprti podatki, inoviranje in razvoj storitev, vključevanje prebivalcev in deležnikov, portali odprtih podatkov

CILJI TRAJNOSTNEGA RAZVOJA

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sl. – Slovene

AI – (sl. umetna inteligenca); Artificial Intelligence

API – (sl. aplikacijski programski vmesnik); Application Programming Interface

CKAN – (sl. celovita mreža znanja); Comprehensive Knowledge Archive Network

DPI – (sl. digitalna javna infrastruktura); digital public infrastructure

EU – (sl. Evropska unija); European Union

GDPR – (sl. Splošna uredba o varstvu podatkov); General Data Protection Regulation

HRI – (sl. storitev odprtih podatkov v Helsinkih); Helsinki Region Infoshare

HVD – (sl. nabor podatkov visoke vrednosti); high-value dataset

ICT – (sl. informacijsko-komunikacijska tehnologija); Information Communication Technology

LPP – (sl. Ljubljanski potniški promet); Ljubljana Public Transportation

MOL – (sl. Mestna občina Ljubljana); Municipality of Ljubljana

OECD – (sl. Organizacija za gospodarsko sodelovanje in razvoj); Organization for Economic Co-operation and Development

OPSI – (sl. Odprti podatki Slovenije); Open Data Slovenia

PSI – (sl. informacija javnega značaja); Public Sector Information

SDG – (sl. cilj trajnostnega razvoja); Sustainable Development Goal

SOI – (sl. trajnostno usmerjena inovacija); sustainability-oriented innovation

SURS – (sl. Statistični urad Republike Slovenije); Slovenian Statistical Office

UDP – (sl. Urbana Digitalna Platforma); Urban Digital Platform

UN – (sl. Združeni narodi); United Nations

1 INTRODUCTION

At the start of the twenty-first century, fast-paced urbanization made both governments and societies start thinking about solving the issues related to sustainable development, energy transition, education, public services and safety (Rodríguez Bolívar, 2015). Sustainable urban growth and sustainable communities are especially important nowadays because of rapid urban population growth. Due to digitalization and digital technology, numerous cities all around the world have implemented smart city initiatives in their urban development. Smart cities have emerged through a synergy of organizational, technological and political innovations and have brought smart solutions for sustainable urban development across governance, economy, environment, urban mobility and society (Aguilera et al., 2017). In the smart city context, with open data initiatives, city governance can be improved, citizens' active participation is established, collective intelligence and co-operation are encouraged together with new product and service innovation. Moreover, such initiatives can be instrumental in environmental and socio-economic problem mitigation (Young & Verhulst, 2016).

A smart city as a concept does not have a unique definition and a few similar terms are used interchangeably, such as "intelligent city" or "digital city". Despite this notion, most of the existing definitions have something in common which is the utilization of Information Communication Technology (hereinafter: ICT) to improve urban life in a sustainable, citizen-centric and efficient way (Albino et al., 2015). Additionally, Albino et al. (2015) have concluded that innovative use of ICT can help city municipalities improve their interaction with stakeholders and enhance the delivery of services. By adopting emerging technologies and data-driven solutions, smart cities have evolved into interconnected ecosystems while integrating multiple intelligent systems where technologies converge (Gupta et al., 2020). It can also be implied that ICT serves as a facilitator for making novel communicative environments, which requires equitable improvement of creative competences, institutions driven by innovation, collaboration-based virtual platforms and wide band networks (Komninos, 2011). However, while ICT is a prerequisite in smart city development, it is not sufficient on its own to make the city a smart one. A city is to be considered "smart" when human and social capital investments, together with traditional and ICT communication infrastructure, promote a high quality of life and sustainable economic growth (Caragliu et al., 2011).

Furthermore, one of the main contributors to a fully functional smart city is open data. The importance of open data and the possibilities that it brings is visible in the fact that the European Union (hereinafter: EU) has invested in its research (European Union, n.d.). Open data initiatives in a smart city context can improve the public value delivery in dimensions such as economic, strategic, political, governance and citizens' quality of life (Pereira et al., 2017). Additionally, smart cities are a perfect environment for open data generation because of their built-in characteristic to produce large volumes of data (Moustaka et al., 2018). Data,

after being collected and analysed in the urban data ecosystem through various sensors implanted in machines, devices, urban infrastructure and facilities, is used for making predictions and offering valuable insight for city development. Furthermore, it aids in introducing new models for sustainable urban growth (Aguilera et al., 2017). So, one of the main reasons why governments decide on open data initiatives is to make data available, so it promotes better transparency, improves economic growth and public services, supports innovation, fights against corruption and reaches sustainable development goals (Berrone et al., 2016).

In 2023, around 56% of the total world population lived in urban areas, which translates into approximately 4.6 billion people (World Bank, n.d.). Furthermore, there is a prediction made by researchers that 70% of the world's population will live in cities by the year 2050 (Anthony Jnr, 2024). An increasing number of people living in cities means that the energy consumption in the cities is increasing, too. According to the International Energy Agency (2024), cities account for up to 75% of worldwide energy consumption. Therefore, cities have large potential in leading the energy transition, reducing emissions and other negative impacts on the environment, while supporting economic growth and positive change.

As a response to supporting and accelerating climate neutrality, the Municipality of Ljubljana (hereinafter: MOL) decided to take part in the European Commission's Mission 100 Climate Neutral and Smart Cities 2030 (City of Ljubljana, n.d.). This mission is addressing climate change and the efforts of various European cities to decarbonize as soon as possible. In total, there are 112 cities (100 from the EU and 12 from non-EU countries in Europe) that are committed to sustainable development and achieving highly ambitious climate and environmental goals (Mestna občina Ljubljana, 2024).

Additionally, the MOL has a Digital Development Strategy for the period from 2023 to 2027 as one of the approaches to achieving environmental goals, becoming carbon-neutral and a smart city (Mestna občina Ljubljana, 2023a). The main purpose of such a strategy is to help them manage and supervise the digitalization process, while primarily focusing on the benefits it could bring to the citizens of Ljubljana. Under the fourth strategic goal, it is stated that data management has become more challenging due to digitalization and the increased number of automated processes. Thus, a lot of effort will be put into responsible and comprehensive data management (Mestna občina Ljubljana, 2023a). Consequently, preparations of making open data available for citizens, companies, educational and other organizations are underway (Mestna občina Ljubljana, 2025). Currently, there is a national open data publishing point for the whole public sector named Open Data Slovenia (sl. Odprti podatki Slovenije, hereinafter: OPSI) (Ministrstvo za javno upravo, n.d.). This portal contains various datasets in relation to sectors like agriculture and environment, transport and logistics, health, public services, economy and others. Open datasets related to Ljubljana, published either by the MOL itself or other public institutions, are available on OPSI portal, however, with limited availability. Hence, the MOL decided to develop and publish its open data on its Urban Digital Platform (hereinafter: UDP), which is currently

being developed. Publishing open data and utilizing it as one of the most crucial resources in smart city service development represents a significant opportunity for the MOL to enhance urban domains like economy, education, environment, energy, transport, health and citizens' quality of life and consequently, officially receive the title of a smart city (Ojo et al., 2015). Moreover, through the provision of open data, governments support citizens, researchers and businesses to freely obtain, use and share these resources, which leads to fostered innovation, enhanced transparency and solving societal issues (OECD, 2025). However, there are some aspects which need to be considered, such as the performance measurement or framework while implementing open data initiatives and meeting the citizens' expectations. Hence, open data initiatives need to be demand-driven for smart service development to be effective and sustainable (Neves et al., 2020). Furthermore, according to van Ooijen et al. (2019), the full potential of open data utilization in the public sector has yet to be realized. Hence, it is important to explore how municipalities can effectively utilize the benefits of open data to enhance smart service development and foster innovation.

In my master's thesis, I seek to provide an answer to the following research question: "How can open data enhance smart city services and foster innovation in the Municipality of Ljubljana?". The purpose of my master's thesis is to demonstrate how open data, its usage and open data initiatives can improve smart city services and increase innovation within the MOL, in order to enhance sustainability, improve the well-being of inhabitants and support the MOL's transition towards an even more efficient, inclusive and climate-resilient urban environment. Some smart cities in Europe serve as excellent examples in practice (e.g., Helsinki and Kuopio) and have proven that with open data utilization, it is possible to foster collaboration between citizens and other stakeholders and consequently, improve smart city services. Hence, I will explore practical solutions and opportunities which can be implemented in the MOL.

To achieve its purpose, the objectives of the master's thesis are:

- to present the impact of open data and its initiatives on fostering innovation and service development in the smart city context;
- to identify key challenges and barriers to efficient implementation of open data initiatives in smart service development and innovation;
- to present good examples from practice of open data's usage in service development and innovation (e.g., cities of Helsinki and Kuopio in Finland);
- to analyse the national open data portal of Slovenia in order to evaluate the accessibility and usability of open data for supporting smart service development and innovation;
- to analyse historic and current availability and utilization of open data within the MOL, while identifying strengths and gaps that affect service development and innovation.

The master's thesis consists of a theoretical and empirical part. The theoretical part is based on the review of the existing scientific literature and online resources on smart cities, open

data and utilization of open data for the smart service development and innovation. Firstly, the concept of smart cities and their elements are introduced. Furthermore, innovation in smart cities is explained through different types of innovations, such as technological, citizen-centric, sustainability-oriented and open innovations, as they shape and enhance smart city services. Then, open data and its role in smart service development and innovation is described, together with data governance, ethics and privacy aspects. Lastly, two successful examples of open data utilization in cities are represented. The theoretical part serves as a base for better understanding and presentation of the empirical part, which is then split into two methods of research.

In the empirical part of the master's thesis, firstly, I use quantitative methods of research to analyze the national open data portal of Slovenia (OPSI). Namely, I conducted the analysis in a Jupyter Notebook environment by utilizing the Python programming language, which allowed for coding, data visualization and documentation in one place. The Python script was prepared and written with the usage of Generative Artificial Intelligence, namely ChatGPT, which I slightly adapted for better data visualization. The full Python script can be found in Appendix 4. Since many open data portals, including OPSI, use the Comprehensive Knowledge Archive Network (hereinafter: CKAN), which represents an open-source data portal platform, I decided to use their Application Programming Interface (hereinafter: API) with a Python library for the analysis (CKAN, n.d.). Such an approach enabled a systematic and automated way to analyse open data file formats, their machine readability, data update frequency and currently available Ljubljana-related open datasets. The idea for using such an approach also came from the research conducted by Lněnička (2015), who proposed an evaluation framework that could be used for improving open data portals, including open data infrastructures, initiatives and strategies. By analysing current open data availability on OPSI portal and its certain characteristics, including the above-mentioned characteristics of open datasets, especially those containing data related to Ljubljana, I aim to identify strengths and opportunities for further development of open data initiatives in the Municipality of Ljubljana. Based on the qualitative analysis of the interviews, I present key findings. As the interviews contained extensive information and implications for smart service development and innovations, I decided to utilize ChatGPT, in subchapter 6.1, for brainstorming ideas about the areas where research findings would have the most influential impact on smart service development and innovation. Interviews were transcribed using an automated speech-to-text tool called Whisper AI that was executed through a short Python code in the Google Colab environment.

Secondly, qualitative methods of research are included by conducting three semi-structured interviews with professionals from the MOL's Office for Digitalization, in order to analyze historic and current open data utilization, how establishment of new open data portal within UDP can enhance smart service development and innovation in the MOL and lastly, which challenges are present in open data collection and publication within the municipality. The primary motivation was to gain in-depth, practice-oriented insights into how open data for

citizens, businesses and other stakeholders and consequently, open data utilization, have changed and improved the municipal service development and innovation. Furthermore, I explored how the MOL engages with its residents and external stakeholders. Together, these interviews help validate the key findings of the thesis and contextualize Ljubljana's smart city efforts in relation to open data utilization for service development and innovation.

2 SMART CITY CONCEPT

2.1 Definition of a smart city

According to Gartner (n.d.) the term digitalization translates to the "use of digital technologies to change a business model and provide a new revenue and value-producing opportunities". Due to its wide applicability, digitalization can affect different aspects of our lives, from personal relations in terms of the usage of social media, to public services, like e-government, which include interactions with other citizens. When it comes to public services, digitalization and various digital products have transformed the approach how public services are used by citizens (Jussila et al., 2016). Other examples of digitalization include smart houses, smart mobility, e-health, including smart cities (Gray & Rumpe, 2015).

Due to growing number of urban population and pressing climate change issues, cities need to become more sustainable in very short period. To do so, researchers state that cities need to be "smart" to improve their sustainability (Bibri & Krogstie, 2017). Therefore, the concept of a smart city has gained a lot of attention among researchers and governments all around the world. Since each city is in its own phase of development and has specific requirements, there is no universal approach of transforming a city into the smart one. However, in general, one could agree that a successful smart city development should comprise of active citizen participation, combination of different solutions within a portfolio of initiatives and knowledge-sharing by local government within the network (Manville et al., 2014).

European Commission defines a smart city as "a place where traditional networks and services are more efficient via the use of digital and communications technology for the benefit of its inhabitants and business" (European Commission, n.d.-a). On the other hand, Mohanty et al. (2016) concluded that the smart city as a concept still does not have a unique definition that researchers and academia have agreed on. However, in simple terms, smart city can be defined as a place where traditional services and networks are transformed to become more efficient and sustainable by using information, telecommunication and digital technologies. By getting more efficient, inhabitants are offered with improved public services while the city becomes greener, safer and with better resource utilization (Mohanty et al., 2016). Similarly, Gassmann et al. (2019) state that in smart cities digital technology is implemented thoroughly, so that the resource input is reduced, citizens' quality of live is improved and competitiveness of regional economy is enhanced but sustainably. They also

note that smart solutions are utilized for energy, housing, mobility, infrastructure and security, which are grounded in the system of sensor technology, data analytics, connectivity and functionally autonomous processes with value-added. Overall, the definition of a smart city concept always depends on a particular context. It can depend on target objectives, accessible resources, finances, policy frameworks of a particular country or a city. Additionally, it relies on the latest research and advancements in ICT field, in terms of technologies, models, systems and applications used (Bibri & Krogstie, 2017).

The opinion on the origin of a smart city concept differs among researchers. According to Anthopoulos (2015), the smart city term firstly appeared in the literature in 1998, as part of the research conducted by Van Bastelaer (1998). On the other hand, Gabrys (2014) states that the concept originates back to 1960s, when it was defined as "cybernetically planned cities". According to Dameri and Cocchia (2014), it appeared close to the end of 20th century, more specifically in 1994. Lastly, Batty et al. (2012) believe that the smart city concept is relatively new and has been incorporated in the city planning as the movement of smart growth started to appear. Only after the EU started promoting and supporting smart city projects in 2010 did the concept gain its significance and the number of academic publications on this topic has increased (Jucevičius et al., 2014).

According to Bibri and Krogstie (2017), two prevailing approaches to smart cities can be distinguished, the ICT-oriented approach and the people-oriented approach. Namely, the ICT-oriented approach is focusing on making technology, in terms of communication, transportation, energy, waste management and hard infrastructure more efficient with the help of ICT. On the other hand, people-oriented approach pays more attention on soft infrastructure and human capital when talking about safety, fairness, knowledge, citizen involvement in smart city projects and similar factors. For instance, Marsal-Llacuna et al. (2015) represented ICT-oriented approach on the example of how smart cities focus on monitoring and improving available infrastructure by utilizing data analytics and ICT, with a goal to give citizens access to more efficient services and promote innovation within business models in private and public sector. Regarding the second approach, the people-oriented approach, Neirotti et al. (2014) depict the smart city as a place where citizens' quality of life is improved. This can be achieved through active citizen participation and application of innovative thinking (Vanolo, 2014).

Ismagilova et al. (2019) explored the definitions of smart cities in the Information Systems literature and emphasized the importance of citizens, who were mentioned in several studies. One of such studies, conducted by Ortiz-Fournier et al. (2010), provided a definition of smart cities in the context of smart citizens and their educational level, knowledge, quality of social interactions and overall openness to global perspectives. With skilled, educated and open-minded inhabitants, cities are better equipped to adopt modern urban concepts that require transitioning towards new paths. Overall, creating public value should be the focus and one of the main roles of urban areas, hence, objective of crucial importance for smart cities (Gassmann et al., 2019). In this context, open data emerges as a key enabler because open

data initiatives can improve public value delivery in economic, political, strategic dimensions and citizens' quality of life, to name a few (Pereira et al., 2017).

2.2 Smart city elements

There are various divisions of smart city elements in the literature. For instance, according to Giffinger et al. (2007) and Gassmann et al. (2019), six smart city elements or dimensions can be distinguished, enabled by digital technologies that are usually incorporated into innovative business models. Those six elements are smart mobility, smart living, smart environment, smart government, smart economy and smart people. From the strategic perspective, such six-element division is considered as a holistic way of designing smart cities (Giffinger et al., 2007). Therefore, I decided to adopt this division in my master's thesis.

2.2.1 Smart mobility

Transportation and road infrastructure represent an important segment of any urban area. Their vitality contributes to the liveliness of a city. Safe and efficient transportation largely depends on the world economy and everyday life. Additionally, mobility in smart cities aims to ensure safety of pedestrians and drivers, sustainable development and the interconnectivity of transport systems by using ICT infrastructure (Li et al., 2020).

Urban mobility comes with a lot of challenges as well, such as long commuting times and traffic congestion. However, many cities have managed to implement innovative and effective solutions in this area. Some of the solutions include bike and car sharing systems, traffic guidance systems, smart traffic lights, parking spaces equipped with sensors, and autonomous public transportation. Initiatives under smart mobility share several common characteristics and objectives, such as sustainable and secure transport system, good availability across the whole city and addition of nonmotorized vehicles. Lastly, it is important to note that cities do not need extensive transformation to enhance their urban mobility services. With relatively small but consistent improvement steps, they can provide a substantial positive effect on citizens' lives (Gassmann et al., 2019).

2.2.2 Smart living

Services that provide a higher quality of life for citizens fall under the smart living category. More specifically, such services encompass healthcare, security, cultural facilities, housing quality, social cohesion, education and attractiveness of tourism. In many of them, information and communication technologies have already been and are being implemented. Some of the most popular and common examples are virtual guided tours and healthcare system digitalization. Furthermore, police departments have also been providing support through data-driven analysis (Gassmann et al., 2019).

According to Kumar (2020), a smart city should provide an environment where its inhabitants can live a high-quality life. For smart living to exist, a city has to have shared values, celebration of local history and culture, provide easily accessible and high-quality public spaces, ensure the safety of the citizens, offer high-quality public services and provide an ideal space for the everyday life of all citizens, from the young generations to the elderly.

2.2.3 Smart environment

The focus of this domain is lowering the ecological footprint while maintaining high quality of life and improving smart mobility. Moreover, smart environment involves preserving green areas, minimizing the soil sealing and new urban planning concepts at the micro and macro level (Gassmann et al., 2019). Parasher et al. (2019) propose a few solutions to be realized for future smart cities, if they want to reach a smarter environment. The solutions are the following:

- adopting relevant procedures for ecological landscape design in city planning area;
- developing fuel- and energy-efficient transit systems;
- using sustainable manufacturing methods;
- producing energy-efficient ICT equipment;
- selecting sustainable practices of collecting, managing and disposing waste;
- generating specific enzymes for detection and treatment of imminent pollutants.

In Ljubljana, for instance, greening the roofs of bus stations helps with reduction of heat absorption, especially in the summer months (Mestna občina Ljubljana, n.d.-a). By doing this, the air quality improves because plants capture pollutants and greener bus stops lead to more pleasant and calming city environment. Another example from Ljubljana is late mowing in Tivoli Park and other green surfaces during the summer months. The reason for this is supporting bee populations and other insects to find food and shelter. In such way, the diversity of insects is kept stable, plants flower better, and pollination success is higher (Mestna občina Ljubljana, 2023b). Interestingly, more and more apiaries are seen on the rooftops of buildings, shopping centres and hotels in Ljubljana. However, so-called “urban beekeeping” concept is not new and started successfully back in 2010 in Ljubljana (Mestna občina Ljubljana, n.d.-b). It was also tested and confirmed that the quality of such honey is very high, despite the assumptions that air pollution in city centre area of Ljubljana would not allow production of high-quality honey.

To sum up, when discussing about smart environment in general, eight different themes are considered as part of it: energy efficiency, environmental protection, pollution reduction, sources of renewable energy, sustainable resource input, environmental conditions’ attractiveness, sustainable housing and city planning (Gassmann et al., 2019).

2.2.4 Smart government

Giffinger et al. (2007) highlight smart governance as an essential dimension of smart cities, defined by the relationship between the citizens and the city government in charge. Moreover, good city governance is connected to the use of novel channels of communication for citizens, e.g. "e-governance" or "e-democracy". As municipal services are offered online, there is a lot of data to be collected and processed. These services are closely connected to ICT, which serve as an inter-connection point between private, public and civil organizations. The reason for this is to enable the city to function effectively in the implementation and management of smart city initiatives within a connected urban system focused on its citizens.

Initiatives within smart government are primarily developed to promote active participation of inhabitants and make administrative structures more transparent. Citizens' active participation can be achieved by providing them with digital services via computers or smartphones. Moreover, there is a huge potential in designing and developing completely new approaches to decision-making and urban governance. Smart government activities comprise of active citizens' participation, transparency, open data, e-government, ICT and various services within municipalities (Gassmann et al., 2019).

2.2.5 Smart economy

According to Giffinger et al. (2007), there are seven factors of smart economy, such as culture of innovation, entrepreneurial activities, trademarks, productivity, labour market adaptability, global integration and transformation ability. For example, labour market adaptability and enhanced productivity can be achieved by utilizing smart production and innovating products and services for the citizens.

Elements included in the smart economy area have a common objective, which is to enhance the competitiveness of the city. Numerous cities all around the world are putting their efforts into creating innovation ecosystems, where start-ups, private companies, city municipalities and other stakeholders are collaborating, with a goal to support smart city development with innovative solutions and business models. With new technological solutions being applied, improvements can be seen in productivity, drive for innovation, entrepreneurship, networking and labour market flexibility. However, smart economy service area within smart city concept is often overlooked, despite its considerable potential for expansion and fertile ground for innovative ideas and business models (Gassmann et al., 2019).

2.2.6 Smart people

This smart city's dimension has the objective to keep and enhance the current human and social capital. Additionally, it refers to the citizens' capacity to fully realize their potential

and actively participate and contribute to the public and social life. During the early days, smart city concepts prioritized the use of digital technologies to enhance the communication among citizens and eliminate the sense of anonymity which is often associated with urban areas. Furthermore, by offering consulting sessions and making online courses open to citizens, their competences can be increased. Lastly, the smart citizens dimension aims to improve essential individual competences, ethnic and social diversity, citizens' creativity and open-mindedness, engagement in lifelong learning and public life overall (Gassmann et al., 2019).

2.3 Innovation in smart cities

An idea, practice or object which is considered as new by a person, or any other adopting party is defined as an innovation. The reactions of individuals are dependent on the perceived newness of the idea. Thus, it can be said that an idea is an innovation if it is new in someone's eyes. However, newness in innovation does not just translate to a new knowledge. An individual may have been familiar with the innovation but has yet to form a clear opinion on it and if it should be adopted or rejected (Rogers, 2003).

As a form of urban innovation, smart city initiatives have the main characteristics found in most of innovations (Ojo et al., 2015). Such characteristics are compatibility, complexity, relative advantage, trialability, observability (Rogers, 2003). Wisdom et al. (2014) include and describe additional characteristics, which were found in previous theoretical frameworks, such as cost-efficacy and feasibility, risk and evidence. All these characteristics affect the successfulness of adoption and implementation of a specific innovation. If we talk about the smart city context, such characteristics can be described in certain ways. For example, relative advantage is the extent to which the initiatives of smart cities are recognized as enablers of a better city life, which can be calculated as an effect of the initiative on the smart city domain. Compatibility measures the consistency between the initiative and the current values of stakeholders and the smart city context. Complexity represents the difficulty level included in the initiative implementation and communication of related advantages to stakeholders. Trialability means to which extent is experimentation possible. Cost efficiency and feasibility translate to the cost effectiveness of the new initiative compared to the current practice. Evidence means if the research has already been conducted on the initiative's efficacy. Lastly, risk refers to the level of uncertainty if the initiative would be adopted and implemented (Ojo et al., 2015).

Ojasalo and Kauppinen (2016) observe that cities are no longer producing and buying services but innovating them. They also add that innovating services is rarely a simple and straightforward process. However, bringing stakeholders together and using co-creation platforms make innovation process more dynamic and interactive, yet quite uncertain. For this reason, responsible smart city stakeholders, such as city departments or authorities, must be actively engaged and well-informed since they are expected to support and advance smart

city initiatives (Rogers, 2003). Such involvement is facilitated through various channels, like public events, policy briefings and specific instructions from city administrators (Ojo et al., 2015). Hence, it can be concluded that successful innovation in the smart city context requires various stakeholders who need to collaborate. The following subchapters will describe different ways how such collaboration can be achieved, beginning with the role of smart cities in driving technological innovation and continuing with a specific focus on citizen-centric service innovation, co-creation and co-production as citizens are the end users of public services and play a crucial role in shaping demand and the overall effectiveness of smart city initiatives.

2.3.1 The role of smart cities on technological innovation

The role of smart cities on promoting technological innovation can be seen in different aspects. On the one hand, agglomeration theory states that smart cities can promote the creation, dispersion and gathering of knowledge and support the exchange and advancements in science and technology (Caragliu et al., 2016). On the other hand, building smart cities can improve the allocation efficiency of different factors and thus, improve the urban innovation efficiency (Shu et al., 2024). To promote emerging industries and advance public service together with urban development, smart cities can depend on blockchain technology, big data and other digital technologies (Shu et al., 2024). Consequently, this can cause a large inflow of highly qualified and educated people in the city, which improves the structure of human capital (Praharaj et al., 2018). With improved human capital structure smart cities can establish an enhanced base of innovation. Additionally, smart cities allow companies to improve information gathering on government policies and market situation, which lowers companies' operating costs and time spent on gathering information (Shu et al., 2024). Simultaneously, smart cities facilitate accurate information gathering of companies by financial institutions, which lowers the data imbalance between companies and financial institutions (Guo et al., 2022). Such information gathering results in improved credit access and hence, companies can obtain more funds to invest in innovation (Yu et al., 2021).

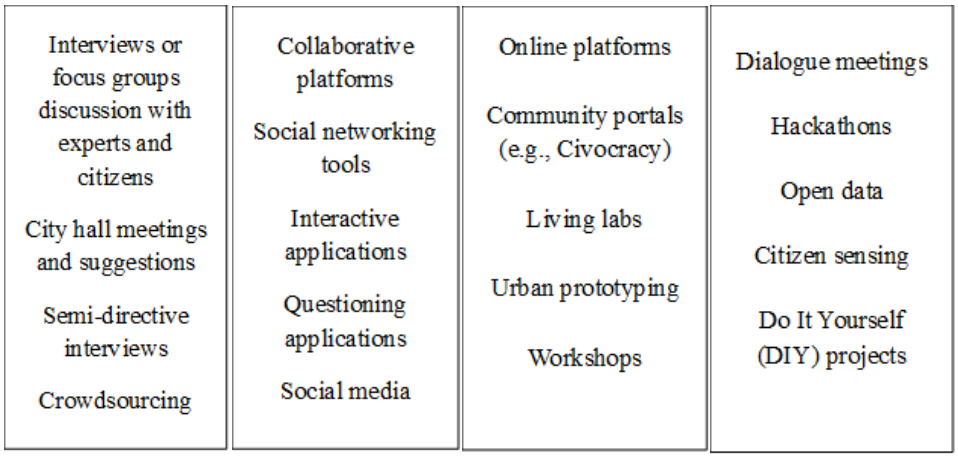
Furthermore, smart city development enhances distribution of technological resources (Shu et al., 2024). There are two main reasons why this happens. Firstly, smart city development stimulates the development of urban intelligence, promotes the expansion of high-technology industries, increases demand for research funding and technology specialists, which all results in more feasible technological resource funding (Niebel et al., 2019). Secondly, thousands of data is being collected and processed by the network systems installed within smart cities, which lowers information exchange and information imbalance costs, hence improves factor market allocation effectiveness (Wang et al., 2019). However, innovation is usually defined by high input costs, time-consuming research and development and increased risks. Such obstacles are tackled by a reasonable distribution of technological resources, which, in turn, stimulates regional technological innovation (Shu et al., 2024).

This is the case because technological resources comprise both physical and informational support for the technological innovation activities on a regional or country level, together with technology specialists and funding as essential elements (Yeung & Coe, 2015). City governments can mitigate financing and research pressure on companies, reduce uncertainty risks connected with companies' innovation processes and promote enthusiasm for technological innovation by increasing technology spending and introducing incentivizing policies for technology experts. Therefore, the circulation of production factors is headed towards innovative sectors, which aids technological progress (Shu et al., 2024).

2.3.2 Citizen-centric service innovation and co-creation

Co-creation for urban innovation represents a new approach where municipality and urban community utilize their collective knowledge, skills and expertise to collaboratively make new urban services which serve citizens and the local surroundings (Akterujjaman et al., 2022). Within the same urban context, it has been proven that a positive relationship exists between open innovation and stakeholder engagement (Paskaleva et al., 2015). Consequently, co-creation represents an essential component in a larger transition for community engagement areas within the municipality, establishing relationships between academia, public and private sector and voluntary stakeholders (Kloppers, 2016). Inside of the EU area, European Innovation Ecosystems act as a support for companies to scale up their business, encourage innovation and foster cooperation between national, regional and local innovation stakeholders (European Commission, n.d.-b).

Figure 1: Approaches to community engagement for co-creation of urban innovations



Source: adapted from Anthony Jnr (2024).

For a better understanding of community engagement for co-creation of urban service innovation in smart cities, we can focus on different approaches on how to employ it, as shown in Figure 1. According to Anthony Jnr (2024), these approaches are based on the best practices that have been identified from the available literature. Due to their specific importance, I will explain them further in the following paragraphs.

The first group of approaches, which can be seen in the far-left rectangle, represent interaction approaches used to gather ideas, such as conducting interviews or focus groups discussion with experts and citizens, city hall meetings and suggestions (Simonofski et al., 2019). Semi-directive interviews are used for recognizing citizens' crucial requirements when it comes to potential future urban projects. Lastly, crowdsourcing is utilized for collecting data from a large group of citizens via the internet (Larios et al., 2016).

The second group of approaches, such as collaborative platforms, social networking tools, interactive and questioning applications, are usually used to lower the costs of community engagement by allowing citizens and other stakeholders to co-create urban services through the usage of their mobile devices. This is done remotely, at the time that is the most convenient for the users, with an aim to enhance democratic debates while promoting citizen engagement (Granier & Kudo, 2016). Social media is mainly used as a medium for engaging with the community by involving a greater number of citizens (Leclercq & Rijshouwer, 2022).

The third group of approaches comprises of online platforms, community portals, living labs, urban prototyping and workshops. Online platforms, for instance, are used for gathering opinion from citizens on various public topics. For example, community portal named Civocracy provides recommendation services to municipalities to complete their co-creation operations. Additionally, it offers a digital platform designed to connect citizens and other stakeholders in urban matters by giving useful information and facilitating the dialogue (Simonofski et al., 2019). Furthermore, the concept known as "living labs" serves as open innovation ecosystem driven by communities and is based on cooperation between citizens, government and private businesses. Consequently, they facilitate multi-stakeholder engagement in urban service innovation development (Rubalcaba et al., 2022). Living labs also serve as playgrounds for open urban service innovation. They can aid in carrying out market evaluation, exploration of urban ideas and lowering the business risk for companies running inside of the city (Simonofski et al., 2017).

The last group of approaches is used in the planning phase of co-creation of urban innovations. It consists of various dialogue meetings, citizen sensing, open data and hackathons, which are usually organized by universities in collaboration with local firms and citizens (Axelsson & Granath, 2018). Open data can be described as non-restricted and non-confidential data that is created in public and distributed without any constraints on its circulation or use (Capdevila & Zarlenga, 2015). Open data is used within co-creation for urban service development because it is obtained from various stakeholders and utilized to address perplexing urban issues, like managing public transport and traffic jams (Ma & Lam, 2019). Additionally, it can produce innovative business opportunities for citizens, local companies and be operated to enhance the transparency of urban administration (Capdevila & Zarlenga, 2015). Furthermore, open data is used for creation of open-source platforms and applications which are meant to support collaboration among citizens with a goal to tackle urban challenges (Simonofski et al., 2019). Lastly, projects known as "Do It Yourself" are

utilized as a tool for enhancing urban innovation by getting citizens involved through sensing technology and participatory media (Mahajan et al., 2021).

Community participation has been encouraged within municipalities in emerging countries by involving co-creation activities which promotes citizen-driven initiatives that help build legitimacy in the decision-making process. Hence, society's engagement is necessary for making cities smart and sustainable (Anthony Jnr, 2024). For a municipality to advance its smart city outlook, the cooperation of various stakeholders from the very start of the urban project is required (Gutiérrez et al., 2017). Thus, as mentioned before, there needs to be collaboration established between the municipality, private sector and universities, so that urban innovation development can be advanced. However, Anthony Jnr (2024) emphasizes that this calls for a detailed planning from the municipality itself. On the other hand, citizens are expected to be accountable for promoting community-led initiatives to get the necessary visibility and recognition (Kummitha & Crutzen, 2019). Consequently, municipalities should encourage and include citizens in community-led participation because they have a better understanding and knowledge of their neighbourhoods and play a key role in shaping subsequent co-creation processes (Gutiérrez et al., 2017). Citizen engagement is also enhanced by implementation of technologies within the city. So, city municipalities are bound to implement new technological infrastructures to support urban development (Anthony Jnr, 2021).

Not only can community engagement be enhanced by using different digital and physical methods, but stakeholders' engagement as well (Haustein & Lorson, 2023). As explained in the paragraphs above, there are various approaches which can be used to gather stakeholders' data and opinions, such as surveys, focus groups, social media, dialogues, workshops, discussion forums and city hall meetings (Berntzen & Johannessen, 2015). In the city's physical public space, by organizing informal interviews and meetings with various stakeholders, there is a better understanding of citizens' needs and interests (Fredericks et al., 2020). Alternatively, digital public space gives such stakeholders the opportunity to engage through digital platforms, while enhancing community engagement process since it covers a wider range of participants (Karadimitriou et al., 2022). Another advantage of the digital platforms, like discussion forums and social media, is that they can promote citizen input, especially from those who are reluctant to participate in physical focus groups or city hall meetings because of time or space limitations (Simonofski et al., 2017). Utilization of digital platforms can help reduce these limitations by allowing citizens to take part in decision-making processes. However, Berntzen and Johannessen (2015) highlight that it is essential for municipalities to clearly communicate beforehand what kind of input is needed and how it will support urban development.

2.3.3 Open innovation of services through co-production

According to the literature on service innovation, open innovation has already been recognized as one of the most promising emerging approaches that has challenged research on service domains (Vargo et al., 2008). Not only that, but it has also challenged the public service innovation (Osborne et al., 2014). According to Chesbrough (2011), open innovation is defined as a new framework for management in the 21st century. Additionally, he was the one who came up with the term open innovation itself in 2003. In this case, co-creation with service users facilitates sustainable business models which stimulate uninterrupted value creation for service users. Even though open innovation has been extensively utilized in the private sector, numerous researchers highlighted differences and similarities between public and private sector innovation (Paskavela & Cooper, 2018). According to Bommert (2010) and Hilgers and Ihl (2010), innovation within the private sector is prone to concentrating on the development of new products and achieving competitive advantage. On the contrary, innovation within the public sector is mainly focused on service performance advancement and providing added value that benefits the public. Same as in the private sector, city-related issues can be resolved both internally and externally by utilizing innovative ideas which arise through collaboration between the citizens and the government (Paskaleva & Cooper, 2018). However, innovation is very repetitive and complicated process where project management, teamwork, experimenting and doing pilot runs are essential to the success of innovation management (Hartley et al., 2013). By utilizing participative open innovation like living labs, for example, cities can enforce societal and technological dimensions at the same time to promote community centric services (Paskaleva et al., 2015). Such research is based on community engagement, which has been confirmed to be a valuable approach for incorporating social sustainability into smart city development (Capra, 2019).

As service economy has grown in the last couple of years, understanding of service delivery has changed profoundly in the public sector. City services are not delivered solely by the specialists in public agencies, but also co-produced by the users and related communities (Paskaleva & Cooper, 2018). Public service-related theoretical concepts have switched to citizen-centric and community co-production approaches (Pestoff, 2012). Thus, a novel model of public service provision has arisen, and it is known under the term “co-production”. It is usually defined by the user or citizen engagement in the public services provision (Nabatchi et al., 2017). According to Pestoff (2012), propositions are made in such a way that the citizen co-production is connected to results like effectiveness, responsiveness and efficiency. However, this new approach of co-production has led to changes within traditional ideas of public service management to reflect co-production as a means of fostering collaboration between the public sector and citizens. Consequently, this suggested more efficient use of assets, resources and contributions aimed at achieving better outcomes (Sicilia et al., 2016). It is also important to differentiate between co-production and voice-based participation. Co-production is primarily focused on cooperation co-commissioning and services’ delivery (Bovaird & Loeffler, 2012). As part of this scheme, citizens are no

longer seen as passive users of public services because their skills and experience are thoroughly acknowledged and utilized (Bang, 2005). Service innovation can be extensively affected by co-production in terms of the demand and services' quality (Chen et al., 2011). Such effects can be positive or negative, which is greatly dependent on the expertise and engagement of partners included (Pestoff, 2012). If service organizations can strengthen their ability to handle co-production, they can extend their open innovation capacity (Paskaleva & Cooper, 2018).

From a normative standpoint, service co-production should be incorporated in every stage of the public service cycle, from decision-making, design, production to evaluation (Cahn & Gray, 2013). This cycle of public service development is supported by multiple organizations in the urban municipalities and citizens usually pose advanced demands when it comes to service quality and service nature. Hence, service managers should obtain new roles, apply novel management methods and expand skillset which assures that all actors will receive decisions about public services at every stage of development via collaborative approach (Paskaleva & Cooper, 2018). Additionally, to secure efficient co-production in practice, co-producers have to participate in the evaluation stage, too (Bovaird & Loeffler, 2012).

In the efforts to enhance public services, numerous cities globally have been focusing on open innovation programs and modern technologies to design smart city services (Paskaleva & Cooper, 2018). Smart city pilot projects established between years 2007 and 2013 during the EU 7th Framework Programme for Research addressed transnational societal challenges in the areas of environment, climate change, energy, ICT, security, poverty, employment and many more. The successor programme to EU 7th Framework Programme for Research was Horizon 2020 that focused on solving issues mainly in research and innovation (European Commission, 2016). Such programmes inherently were tailored to be citizen centric. ICT are leveraged in smart cities to improve citizens' quality of life and hence, government stakeholders are supposed to promptly respond to citizens' needs since service users represent essential part in development processes (Paskaleva & Cooper, 2018). Co-creation of services with stakeholders and users is welcomed because it leads to more innovative and effective public services which can lead to higher level of citizen satisfaction (Osborne et al., 2016).

2.3.4 Sustainability-oriented innovations

Sustainable development and urban development are strongly interconnected, especially nowadays as we are faced with various environmental challenges and negative impacts of urbanization. Thus, making cities greener and lowering the carbon emissions, among other related initiatives, serve as a baseline for economically stable, socially responsible and environmentally sustainable future. Sustainable development policies aim to tackle a variety of challenges like urban expansion management and congestion management, to promoting

good practices as competitiveness, social inclusion and sustainability-oriented innovations. All these efforts are connected to the goal of achieving Sustainable Development Goals (hereinafter: SDGs), more specifically SDG 11 (Sustainable Cities and Communities) and SDG 9 (Industry, innovation and infrastructure). Moreover, through innovative financing and targeted digital infrastructure support, SDG tracking and implementation can be enhanced, relating to SDG 17, focused at Partnerships for the Goals (OECD, n.d.).

The goal of sustainable urban development is to enhance the quality of life of the citizens by promoting sustainability-oriented innovations or shortly SOIs (Yigitcanlar & Teriman, 2014). According to the latest United Nations (hereinafter: UN) SDGs Report, creating such sustainable and resilient cities requires increased and coordinated investments in green public spaces, public transportation, affordable housing and inclusive governance. Additionally, more focus should be put on underserved areas together with climate-smart urban planning through participatory and inclusive approaches (United Nations, 2025). Furthermore, certain approaches in urban development, like "more-than-human" and "post-anthropocentric", have been highlighted as significant because they bring increased awareness of non-human aspects in design, biocultural diversity and addressing the complexity of long-term environmental goals (Clarke et al., 2019; Yigitcanlar et al., 2019).

SOIs can be present on different levels, such as product, process, system infrastructure and organizational level, where the organizational one encompasses services, delivery and business model levels (Klewitz & Hansen, 2014; Hansen & Große-Dunker, 2013). Within the smart city context, they are needed at all levels. Generally, sustainable urban development is tied to technological innovations (Tura & Ojanen, 2022). However, technological innovations are not sufficient for resolving growing challenges related to sustainability. Hence, according to Adams et al. (2016), changes are required at the system level. Such systemic innovation for sustainability calls for collaboration between citizens and organizations that promotes their creativity and awareness of the existing and potential challenges, including the change of values to promote collective intelligence in problem-solving processes (Goodman et al., 2017). Therefore, it can be implied that sustainable smart city approach can facilitate sustainable urban development. For instance, to build an efficient waste management system, cities need to employ technological innovations which will enable waste sorting and recycling. On the organizational level, SOIs allow retailers and manufacturers to develop product take-back programs. Overall, ICT and other smart technologies make these systems more efficient. However, future efforts should be aimed at strengthening the understanding of connections between different elements of SOI to promote systemic urban development in smart cities (Tura & Ojanen, 2022).

3 THE SIGNIFICANCE OF OPEN DATA IN SMART CITIES

3.1 Definition of open data

Nowadays, we live in the digital age with increasing amount of data being produced every moment. Data has a great potential in numerous fields, which has already been recognized by the European Commission that sees the data as "an essential resource for economic growth, competitiveness, job creation and societal progress". With a goal to make a single data market, which would secure Europe's worldwide competitiveness and data jurisdiction, the European Commission developed the European strategy for data in 2020. As one of its objectives, the European strategy for data aims to increase the accessibility of data by making high value, publicly held datasets in the EU openly available and providing their re-use without any costs (European Commission, 2025a).

The EU defines open (government) data as "information collected, produced or paid for by the public bodies (also referred to as Public Sector Information) and made freely available for re-use for any purpose" (European Union, n.d.). If we observe the EU area, the public sector represents one of the most data-intensive sectors, with regard to the amount of data it generates, accumulates and pays for. For instance, statistics, weather conditions, geographics, publicly funded research projects and online library books represent such data. Open public data denotes Public Sector Information (hereinafter: PSI) which is made available and reusable, ideally with no restrictions (European Commission, 2025b).

The open data movement began to rise at the beginning of the 21st century. Namely, one of the world's biggest open data communities was established in 2004, under the name Open Knowledge Foundation, which has been utilizing advanced digital tools to provide value-added to others with the usage of open knowledge (Open Knowledge Foundation, n.d.-a). One of their first contributions was providing the meaning of "open" in the context of Open Data, Open Knowledge and Open Content (Open Knowledge Foundation, n.d.-b). In their Open Data handbook, open data is defined as "data that can be freely used, re-used and redistributed by anyone – subject only, at most, to the requirement to attribute and share alike" (Open Knowledge Foundation, n.d.-c).

For more than a decade, there has been an increasing number of research papers on the open data movement and initiatives related to it. According to Goldsmith and Crawford (2014), open data movement revolves around the idea that data should be accessible to anyone who needs it and can be used or re-used for any objective. Similarly, open data is characterized as any data which is accessed, modified and shared without any restrictions or for any purpose (Janssen et al., 2012). The systematic opening of data has emerged as a global trend on the national and municipal levels. One of the first countries to introduce their open public data were the United States of America and the United Kingdom. The government of the United States of America introduced the open data portal in 2009 under the name data.gov.

Similarly, in the following year of 2010, the United Kingdom launched the portal named data.gov.uk. Consequently, many cities became early adopters of open data portals, such as Washington, New York and Chicago in the United States of America, while in Europe, Amsterdam, Barcelona, Berlin, Dublin, Helsinki and Manchester were among the first do adopt them, with an aim to promote transparency, foster innovation and improve public service delivery. Ever since then, numerous national, regional and city governments have been continuously supporting open data strategies, together with launching open data initiatives (Khatoun & Zeadally, 2016; Yadav et al., 2017).

3.1.1 The benefits and value of open data

In order to promote data-driven public value creation, van Ooijen et al. (2019) propose an improved management of the Government Data Value Cycle, as shown in Figure 2, which should provide clarity about the data's role in decision making, while helping policy makers and other public officials enhancing their effectiveness. Moreover, with such an approach, they can better predict new trends and needs, create and adopt more innovative approaches within policies and have a better overview and control of the resource management that is needed for addressing the policies' challenges (van Ooijen et al., 2019).

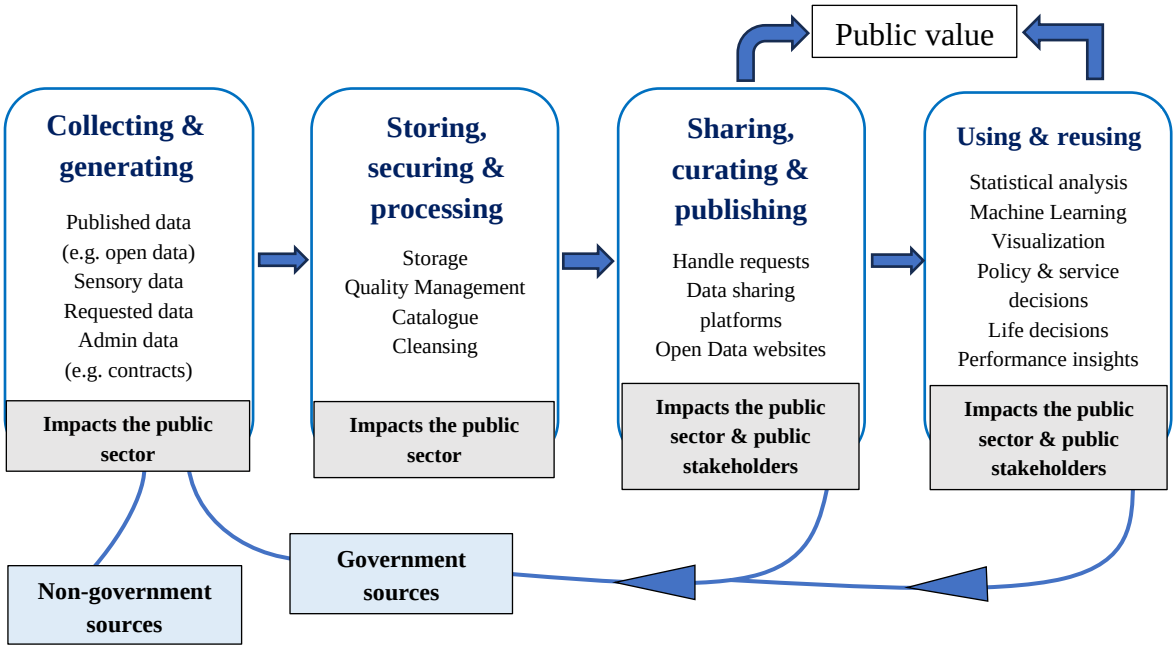
The Government Data Value Cycle consists of four stages:

- data collection and generation;
- data storage, security and processing;
- data sharing, curation and publication;
- data usage and reusage.

The first two stages relate to the processes undertaken by the public sector with regards to handling and taking responsibility for the data it generates, collects and stores. However, the last two are the ones which focus on the opportunities to create public value, either by policy and service enhancement or by harnessing the potential offered through open government data (van Ooijen et al., 2019).

Creation of the public value through data does not occur in a linear manner, but rather in a cyclical one that includes continuous feedback loops. The process of decision-making is influenced and shaped by the data and thus, can result in the generation and collection of new or larger amounts of data. Hence, the Government Data Value Cycle represents a valuable framework for shaping the design of data strategies at both the national and institutional levels. If the government's and citizens' needs are met at every stage of this cycle, data can move more seamlessly into the next stage. This approach is aligned with the goals of advanced digital government by supporting a digital-by-design model that responds to the citizens' and businesses' needs through integrated and end-to-end public services (van Ooijen et al., 2019).

Figure 2: Government Data Value Cycle



Source: adapted from van Ooijen et al. (2019).

By making public sector data available and reusable for different purposes, encompassing commercial ones, the following benefits arise:

- promoted economic growth and innovation by developing new services and products;
- ability to address societal challenges by introducing innovative solutions in areas like transportation and healthcare;
- improved evidence-based policymaking and enhanced efficiency within public administration;
- facilitated participation of citizens in social and political aspects of life, together with increased transparency of the government;
- enabled development of emerging technologies like AI, which relies on the processing of large volumes of high-quality data (European Commission, 2025b).

Furthermore, some of the main areas where the economic value and benefits of open data can be seen are performance, economy and social welfare. The performance area focuses on improving the efficiency of public services and the possibility to control unnecessary spending with the help of cross-sector data sharing. The economy area focuses on the development of innovative services and the creation of new business models, which contributes to the economic growth. The final area, social welfare, aims for the enhancement of the overall participation of different shareholders and the cross-sectional possibilities that free and transparent open data offers to the public. These three areas interconnect with each other, creating considerable benefits for all shareholders across the field, from the governments, cities and large business to the inhabitants of that nation or city (Berends et al., 2020).

Despite the showcased benefits and public value which has been brought by the open data publication and its utilization, the expansion of open data efforts is needed. Namely, Organization for Economic Co-operation and Development (hereinafter: OECD) uses an index known as OURdata Index, which stands for Open, Useful and Re-usable Data, to measure how well open data policies are created by governments, if other stakeholders had been involved in defining such policies and if high-value datasets, which will be explained in the following subchapter, have been published (OECD, 2025). According to 2023 OURdata Index results, it has been demonstrated that governments need to shift the view of open data as a public right to perceiving it as an essential and strategic asset for boosting innovation, economic growth and transparency. Such perception shift needs finding a balance between openness and robust security and privacy protections as geopolitical security concerns have arisen in several OECD countries. Governments and city municipalities can unlock the full potential of their open data, together with trust and responsible governance, if they adjust data policies with growing and shifting digital needs (OECD, 2025).

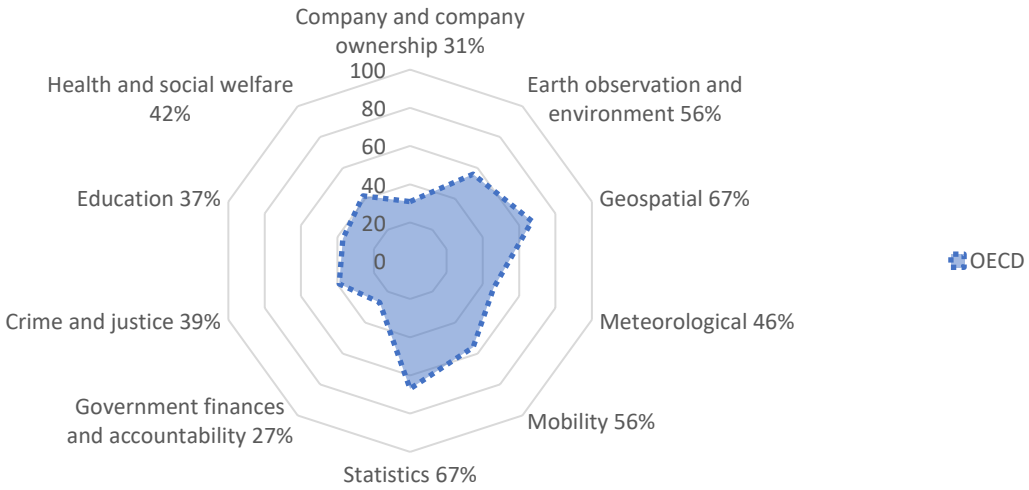
3.1.2 High-value datasets

In 2023, the European Commission published the list of high-value datasets (hereinafter: HVDs) that public sector bodies had to make freely available for re-use within a 16-month period (European Commission, 2023). Such datasets are especially valuable for the ones who want to make and provide services or applications with value-added. Moreover, those datasets provide significant benefits to the society, including the economy and the environment, which is the main reason for making them publicly available. According to the Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (recast), OJ L 172 (hereinafter: Open Data Directive), there are six categories of HVDs: geospatial, meteorological, statistics, companies, mobility, environment and earth observation. However, the range of categories can be expanded to reflect the current technological and market situation. The datasets are provided in machine-readable format, accessible through an Application Programming Interface (API) and where applicable, ready for bulk download (European Commission, 2023). The APIs represent group of rules that enable communication between software applications for data, features and functionalities exchange. Additionally, APIs provide a safe and simple way for making application owners' data and functions accessible to other departments within organizations. Moreover, by using APIs, only the necessary information is being shared while other details from internal systems are not shown, which enhances the security of the system (Goodwin, 2024).

By imposing such a regulation and making HVDs freely available, entrepreneurial activities can be increased and new companies can be established. Additionally, small and medium-sized enterprises (SMEs) can utilize HVDs for the development of new digital products and services, which will, therefore, attract investors. Furthermore, new business opportunities

can arise in logistics and transportation sectors by reusing the datasets that contain mobility data or geolocalization of buildings (European Commission, 2023). Moreover, open access to HVDs can support innovation within public sector and civil society, enhance the efficiency of public service delivery, which represents a great potential for the cities that are on their path of achieving the smart city status, like the Municipality of Ljubljana (OECD, 2025). For instance, by analysing and understanding the traffic patterns from the available datasets, the public transportation can be made more efficient. Research and digital innovation are supported and enhanced by other types of data, such as meteorological, air quality, radar and soil contamination data. This is of vital importance nowadays, as we are facing challenges related to the climate change, pollution, healthcare and education, which calls for better-informed policymaking enabled by reliable and accessible data (European Commission, 2023).

Figure 3: Availability of high-value datasets, OECD average



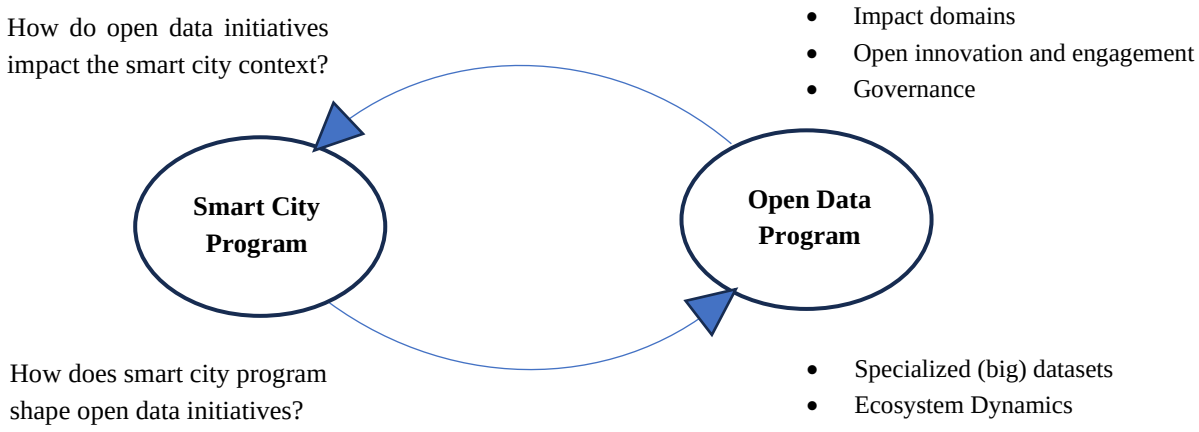
Source: adapted from OECD (2023).

According to the latest collected data from 2022 for OECD survey on Open Government Data (5.0), which included 36 OECD member countries and 4 accession countries, around 47% of HVDs were accessible as open data. As shown in Figure 3, there were 10 categories of HVDs assessed: earth observation and environment, geospatial, meteorological, mobility, statistics, government finances and accountability, crime and justice, education, health and social welfare and lastly, companies and company ownership (OECD, 2023). The datasets which were most commonly available fall into the geospatial information and statistics categories (67% each), with earth observation and environment, and mobility categories close behind (56% each). On the other hand, categories with the lowest availability as open data were companies and company ownership (31%) and government finances and accountability (27%) (OECD, 2023).

3.2 The impact of open data on smart cities

Cities are interconnected through numerous infrastructures, such as transportation, ICT, energy, water, waste disposal that ensure the circulation of the goods, people, information and resources (Lim et al., 2018). Various activities take place in cities on day-to-day basis, and they enable analysis of consumption, transaction and communication patterns. The most common and influential practices are interactions on four different levels: between citizens themselves, citizens and urban environment, between elements of urban environment and between citizens with private sector and public institutions (Khatoun & Zeadally, 2016; OECD, 2015). As an elementary component of smart cities, open data can be regarded as a smart city initiative in the conceptual sense (Ojo et al., 2015). Open data initiatives create urban innovation since open data can be used free of charge by everybody and hence, unpredicted innovations may arise (Ahlgren et al., 2016). Therefore, open data serves as one of the most powerful and effective resources provided to citizens as it affects numerous city domains, like environment, economy, energy, transport, education, health, citizens' quality of life and many more (Ojo et al., 2015). The understanding of open data's alignment within the smart city context is essential and it poses two questions: how is the smart city context impacted by open data initiatives and how do smart city programs influence related open data initiatives. The answers to these questions have already been provided through the study conducted by Ojo et al. (2015) that demonstrates precise evidence of open data initiatives being aligned with their contextual smart city programs, initiatives' direct impact on smart city domains while being created by the smart city context, as shown in Figure 4. Such question is critical for identifying high-value datasets whose release will stimulate real interest and motivation to utilize open data (Yadav et al., 2017).

Figure 4: Aligning open data to smart city context



Source: adapted from Ojo et al. (2015).

Digital technologies in smart cities are not just utilised for improving resource consumption and reducing emissions but also for making traditional services and networks more efficient. The main objectives are to increase operational efficiency, provide and share accurate information with the citizens and offer government services and citizen welfare with an

improved quality. To do so, open data is being widely utilised by businesses, governments and researchers in making better services and products, together with developers who use real-time data, such as transportation or healthcare data, to build new applications or improve the usability of the existing ones (European Union, 2023). By implementing open data initiatives, smart cities are promoting positive social change by enabling citizens to provide their own suggestions and fostering inclusion. Moreover, decision-making location and power are shifted through utilization of open data and implementation of open data initiatives (Davies & Perini, 2016).

Furthermore, open data can enhance the quality of smart cities and make cities more efficient, safer and sustainable in combination with AI. By combining open data and AI, smart city success is elevated. The reason for this is the role of open data as a resource or input for AI systems to work effectively, providing specific and actionable insights. For instance, the city of Dublin has already utilized open data for developing digital-twin technology for data-driven decision-making. Furthermore, the city of Rotterdam has been using real-time data to facilitate transparent decision-making and cooperative urban planning, serving as a good example from practice of how technology can advance sustainable city development (European Union, 2025).

3.2.1 The role of open data in smart service development and innovation

Open data is available to anyone and hence, it can be utilized by citizens, decision-makers, entrepreneurs, private businesses and researchers in various ways, which can advance economic growth and support entrepreneurial efforts of developing innovative services and products (Abella et al., 2017). Hence, such characteristic of open data allows for emergence of new ideas and innovative solutions (Pereira et al., 2017). Kundra (2012) describes open data as "a digital fuel of the 21st century" that promotes new economic activities and leads to progress in innovation. This aspect of open data has been recognized by different governments all around the world which has led to open data publication with a purpose to foster innovation in the delivery of public services, which can be done through external innovation and internal efficiency (Davies & Perini, 2016). Related open data initiatives have usually been connected to Tim O'Reilly's view of "government as a platform" where data published by governments serves as an input for external entrepreneurs or start-ups to produce improved, more efficient and customised public services as an output (O'Reilly, 2010).

Previous studies have shown that open data has had an essential role within creating and innovating services in smart cities. The first example is the study conducted by Ojo et al. (2015) which is explaining how smart cities and open data initiatives congregate. They analysed 18 different open data initiatives in five smart cities, one of which is located in the United States of America (Chicago) and the remaining four are in Europe (Amsterdam, Helsinki, Barcelona and Manchester). After the analysis, it was concluded that open data

initiatives have substantial influence on smart city domains like transportation, mobility, environment, economy, governance, education and tourism. However, two smart city domains, economy and governance, were estimated to get most influenced by open data initiatives in those five smart cities. Furthermore, it was proven that the nature of released datasets in those five cities is assisting innovation in smart city development. Lastly, the researchers concluded that smart cities supported by open data could be defined as "open innovation economies" (Ojo et al., 2015).

Another study was conducted by Pereira et al. (2017) whose purpose was to examine the impact of open data initiatives on improving the results of governmental actions in the smart city context. Their objective was to analyse this in a form of relations and propositions in which open data initiatives serve as inputs for the government to improve the delivery of services and information which aligns with citizens' needs. The first key finding is related to the open data's contribution to the public value. It was demonstrated that open data initiatives can significantly improve the public value within numerous dimensions, like economic, political, strategic and citizens' quality of life. Hence, this implies that open data can lead to enhanced service delivery and innovation. The second key finding highlights open data's role in fostering collaboration among different government agencies, which is essential for development of integrated smart city services that tackle complex urban challenges. Additionally, such collaboration is important for innovation process which can deliver better solutions for citizens. Thirdly, through implementation of feedback mechanisms, such as feedback channels, open data enables communication of citizens' needs and experiences and consequently, directly shape the development of new services and suggest improvements to the current ones. Lastly, this study discusses the positive impact of harmonising the data generated by citizens with government data, which leads to better understanding of city dynamics. Such harmonisation is crucial for service development and innovation, especially in the smart city context where real-time demands should be met timely and effectively (Pereira et al., 2017).

3.2.2 Challenges of open data release, adoption and implementation

Even though the benefits of open data initiatives in the context of smart cities have been identified and progress on their realization has been made, for numerous cities they remain unexplored (Berrone et al., 2016). There are considerable challenges that lower open data implementation effectiveness and need to be addressed prior to their extensive application in smart city development (Ma & Lam, 2019). Previous research suggests there are several groups of challenges which limit the effectiveness and benefits of open data release, adoption and implementation, such as political, legal, financial, technical and organizational.

For example, Conradie and Choenni (2014) identified the barriers to open data release within six local public sector services in the Netherlands and concluded that the type of data storage, the way how data is acquired and utilized by different departments determine how open data

will be released. They describe how municipalities usually represent themselves as a singular entity to the outside world, however, in the real world, there is much more organizational complexity involved. Hence, challenges appear in open data release process. Due to this complexity, city services and organizations handle the data in different ways, which affects open data release, too. For example, organizations that store and use the data in a centralized way can release the data much faster. Another challenge represented addresses the question what type of PSI is suitable for releasing as open data. Depending on two components, privacy sensitivity and copyright restrictions, it was identified that the most suitable data for release is the internally produced one within the public entities. Moreover, various barriers related to the data re-use were identified. For instance, after analysing the local city development service, they concluded that some services are unable to release big amounts of data under a certain license for re-use due to the approaches how it handles the data. Additionally, physical and financial limitations pose a challenge to the city archives what can be digitized, despite the presence of legal frameworks on data release. On the other hand, city libraries can release the data for re-use but copyright limits the re-usability of such data. Furthermore, the sensitivity to privacy increases when the copyright law does not apply to such data. Since this research was conducted more than ten years ago and data release by local governments was still new back then and the benefits, costs and barriers of such data release were underexplored, hence, this represents one of the limitations of this research (Conradie & Choenni, 2014).

Heimstädt (2017) studied the adoption of open data in big cities, such as New York City, London and Berlin, by interviewing employees from public organizations, members of city governments, information activists, researchers and private sector employees. Additionally, his study comprised of qualitative research of various newspaper articles, blog posts, studies and policy documents on how the open data concept got introduced in those cities, its development as a demand towards the public institutions and in which ways these institutions responded to the evolving norm of openness. After completion of the data analysis, it was identified the main challenges were present in the disclosure of data and information, and their decoupling from the core operations. Namely, analysed institutions were selective when sharing authentic data, which included exclusion of certain segments or sharing with particular groups of audience. By doing so, institutions can preserve their core operations by disclosing data connected only to peripheral operations or to audiences unlikely to use it in an irregular way. Another identified challenge, when the selectivity of data and information is not possible, is decoupling by bending information. This translates to sharing authentic data and information, however, in a form that is different from the original one utilized within the institution itself. Lastly, the challenge of decoupling by orchestrating information arises when institutions publish data and information that is altered in order to meet the expectations of external stakeholders about their format and content. As one of the proposed solutions, regulatory bodies should be encouraged to articulate precise transparency demands, while allowing for confidentiality in other information areas. Such approach can

help institutions under pressure to avoid developing costly and unclear strategies (Heimstädt, 2017).

Ma and Lam (2019) investigated the barriers encountered by different stakeholders in the development of open data in Hong Kong. They identified the absence of an official open data policy as the biggest challenge. As a solution, they propose establishing an open data policy which will shift the focus from the popularity and trendiness of open data movements to achieving concrete open data objectives. Such objectives could be achieving economic benefits through open data or promoting cooperation and enhancing governance transparency. They suggest other essential elements to be taken into consideration, apart from objectives. Those elements include data format standardization, updating frequency, anticipated data quality, open data license acceptance and promoting citizen participation. Another challenge they identified is the usefulness of open data. Hence, in order to ensure it, they propose introducing a feedback channel designed for users on particular datasets which need to be updated, controlled by data managers or initiators. When promotion of open data does not rely on financial support and technical guidance, the public sector faces challenges of inadequate supporting structure and outdated legacy software systems. This could be avoided through replacement of outdated public ICT systems by progressive resolutions or by acquiring external support through crowdfunding, for example. Furthermore, numerous restrictions narrow the potential of open data for facilitating further development. As lots of databases are protected by copyright, there is a need for a distinct open data licensing to enable its functional use while avoiding conflicts with creative pieces of work like videos and drawings. When addressing the challenge of inconsistent and scattered data management, better technical guidelines must be provided, so that data can be re-used and machine-readable. Other challenges include lack of incentives for the private sector to share their data and risk-averse policies if the government is aware of its public services' weaknesses (Ma & Lam, 2019).

3.3 Data governance with open data

Data governance serves as the foundation for the effective use of data in the public sector. Adopting a wide perspective on the public sector data governance allows governments to share data, provide solutions for societal needs through data-informed approaches, enable cross-border access to services both to citizens and businesses, promote data-driven experimentation accompanied by emerging technologies like AI and guarantee the quality of data which is being used (OECD, 2021).

As a response to the public consultation on the European strategy for data, which prioritizes people in technology development and facilitates European values and rights, the European Commission published the Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act), OJ L 152 (hereinafter: Data Governance Act). This act

aims to increase trustworthiness in data sharing, reinforce mechanisms to increase improve data availability and reduce technical barriers to data re-use. The Data Governance Act will facilitate the establishment and growth of Common European Data Spaces in strategic areas, such as environment, health, mobility, finance, agriculture, public administration and manufacturing, while involving both public and private stakeholders. Overall, the Data Governance Act strives to make more data available and promote cross-sector and cross-EU data sharing with a goal to bring benefits to citizens and businesses through the power of data. Consequently, this will promote development of innovative products and services within industries and make various sectors more sustainable and efficient (European Commission, 2024a).

3.3.1 European legislation on open data

The EU's Open Data Directive specifies common rules for the EU market for government-held data. This directive allows public sector data and publicly funded data be re-used. Its focus is on the economic aspects of data re-use with an aim to help Member States make data widely accessible for re-use. It does not only address data held by public sector entities on the national level, but also on the regional and local levels. Hence, this encompasses the data held by ministries, state agencies, municipalities and organizations funded by public authorities. Furthermore, Open Data Directive is oriented towards two key principles in the European market, transparency and fair competition. After couple of years, when this directive will be fully incorporated on national levels, those new rules will:

- promote the release of dynamic data, together with the adoption and increased use of APIs;
- limit the number of exceptions under which public bodies currently charge above the marginal cost of dissemination for the data re-use;
- encourage Member States to design policies which will open the access to publicly funded research data and promote the re-usability of research data already available in open repositories;
- enhance transparency requirements for public-private agreements concerning public sector data while refraining from exclusive arrangements (European Commission, 2025c).

The Open Data Directive includes rules which mandate that the European Commission has to, in the future, issue an implementing act, which will adopt a list of HVDs to be made available for free for anyone who wants to use them. The benefits of utilization of such datasets were explained previously in this master’s thesis, in the subchapter 3.1.2. However, it can also be added that such datasets have a big commercial potential and can accelerate the evolution of value-added information products within the EU. Additionally, HVDs constitute crucial data sources for the AI development (European Commission, 2025c).

3.3.2 Challenges in data governance

Even though data serves as a driver of economic growth, innovation and societal progress, in the absence of consistent, understandable and comprehensive data governance frameworks, potential risks exist such as privacy breaches, security gaps and unbalanced access to the data-driven opportunities. Many countries around the world started to impose rules to take the advantage of data's potential while trying to lower its risks. However, the current organization of these rules is inconsistent across different counties. Hence, this lack of organization imposes obstacles in cross-border data flows, coordination of cross-country regulations and brings uncertainty for businesses and governments. Furthermore, the increasingly fast development and usage of AI intensifies these challenges, introducing concerns about data integrity, quality and bias (UNESCO, n.d.). Therefore, there is the need to build the capacity and address the following data governance challenges:

- Gaps in data governance frameworks: unbalanced levels of data protection, security and access are caused by limited or fragmentary policies across countries;
- Complexity driven by AI: due to large amounts of data being used and produced by AI, increasing concerns related to fairness, ethics and accountability arise;
- Regulatory inconsistency: policymakers are faced with issues due to fast emerging technological shifts, cross-country data flows and the demand for interoperable solutions;
- Unbalanced capacity: foundational governance structures are required by some countries, while other countries look for guidance to address challenges in open data, digital trade and AI;
- Unavailable resources: various currently available data governance guidelines are fragmented, too technical or lack precise and actionable steps (UNESCO, n.d.).

As a response to these challenges, the United Nations Educational, Scientific and Cultural Organization (UNESCO) developed an initiative under the name Data Governance Toolkit, which can provide policy solutions for data governance to policymakers and regulators. This initiative will help them design and implement responsible, future-oriented and rights-based data governance policies. Moreover, in alignment with SDGs, it will support sustainable and inclusive digital advancements, while enabling all counties, despite their current capacities, to develop and prosper in the digital era we currently live in (UNESCO, n.d.).

3.4 Open data ethics and privacy

Nowadays, in the digital era, it is crucial to maintain privacy, security and ethics accompanied by open data efforts. Such approach includes protecting personal or sensitive data from unlawful access and sharing, guaranteeing individuals have control over their data. However, due to the increasing number of open data initiatives all around the world, there are new challenges being identified in the management of balanced data privacy and data accessibility (European Union, 2024).

3.4.1 Ethical considerations

Data ethics is the area which encompasses the ethical and moral outcomes of data collection, sharing and usage, particularly data which is personally identifiable. Additionally, it is especially focused on any negative effects on individuals, organizations or society that can be caused by execution of data projects. Overall, data ethics is aimed at fair and non-discriminatory provision and usage of data (Opendatasoft, n.d.).

When services' design and delivery is being transformed, exchanging data between organizations is highly desired for obtaining the value-added. However, this can be followed by the data usage for purposes other than those originally specified at the time of data collection. Hence, it is essential that any personal data is anonymised, biases are identified and addressed, when governments utilize the data for future demand predictions and design potential outcomes. This has become increasingly important when data is used for machine learning and training of neural networks. Using machine learning algorithms is an effective way of making service delivery much faster and processing data beyond human capacity, however, this also comes with some limitations and risks (van Ooijen et al., 2019)

In order to promote ethical usage of data in digital government projects, products and services, the OECD has set ten Good Practice Principles for Data Ethics in the Public Sector (OECD, 2021). One of the main objectives they want to achieve with such principles is to establish better citizens' trust in previously mentioned projects, products and services. The principles are the following:

- Data management with integrity;
- Acknowledgement and observation of applicable government-wide frameworks for trustworthy data access, usage and sharing;
- Integration of ethical data factors in governmental, organizational and public sector decision-making processes;
- Observation and maintaining control over data inputs, particularly those used for informing the development and training of AI systems and implementing a risk-based approach to decision-making automation;
- Clarifying the purpose of the data usage, particularly in the context of open data
- Specifying the boundaries for data access, usage and sharing;
- Being clear, inclusive and open;
- Publishing open data and source code;
- Broadening the capacity of individuals and groups to manage their own data;
- Accountability and proactiveness in risk management (OECD, 2021).

3.4.2 Privacy in the digital era

Open data initiatives aim to ensure that data is findable and that datasets are interoperable, hence, maximising their potential to be re-used both individually and together with other datasets. But such projects usually include distribution of comprehensive datasets and even contain certain amount of data about individuals easily detectable, or data that is sensitive. Even though identifying information can be excluded from the dataset, if enough attributes are published, there is a possibility that the identity of those individuals will be implicitly presumed. One of the ways how this can be done is by cross-referencing and data connection among various datasets and databases. In order to address these issues, there needs to be an established and precise balance between data openness and data privacy protection. Couple of techniques can be applied in this case, such as pseudonymous and anonymous data or data aggregation. As a consequence, detailed data are grouped and published as metadata or statistics. Furthermore, there are many guidelines and regulations available on European and national levels that assure ethical and responsible management of open data initiatives (European Union, 2024).

For example, the High-Level Expert Group on AI provided Ethics Guidelines for Trustworthy AI which represents the basis for ethical principles for AI development and usage, while respecting human rights and providing transparency and fairness (European Commission, 2024b). Another well-known example is General Data Protection Regulation (hereinafter: GDPR) that established strict control on the handling of personal data within the EU, requiring explicit consent for collecting the data and allocating substantial control to the individuals over their personal data. Even though GDPR was drafted and passed by the EU, its obligations apply to organizations all around the world as long as they use or collect the data related to the individuals within the EU. In summary, inclusion of such ethical guidelines and regulations into open data practices is crucial. Thus, with utilization of technologies that enhance privacy and alignment with transparent data governance models, open data's societal benefits can be harnessed while ensuring individuals' privacy (European Union, 2024).

3.5 Successful examples of open data utilization

Some of the best practices of open data utilization include examples from smart cities in the Nordics (Finland, Sweden, Norway, Denmark and Iceland). The reason why I decided to represent two cities in Finland as successful examples of open data utilization for smart service development and innovation is because I have spent my study exchange in Finland and got familiar with their open data initiatives, specifically through Helsinki Region Infoshare (hereinafter: HRI) service, which will be explained in subchapter 3.5.1. Additionally, I provide open data platform for the city of Kuopio, named Datajalostamo Kuopio, as another example of successful open data utilization for smart service development and innovation, available in subchapter 3.5.2.

3.5.1 Helsinki Region Infoshare

The city of Helsinki created its open data portal, known as HRI, back in 2011. This was the first publicly available service in Finland, that allowed everyone to access open datasets. The creation of HRI has helped spark innovations that have helped the citizens of Helsinki. Its main role is to "support city employees in opening up data and to promote the use of the opened data" (Helsinki Region Infoshare, 2024a).

HRI's services are divided into four main sections: the generation of data, the opening of data, the sharing of data and finally the utilization of the data. Within the first section, data generation, main aim is to produce and publish data. The production and publishing of data is done in cooperation with stakeholders from both feedback and requests of data. Secondly, the main aim of making data open for wider use is to assist and coordinate the municipalities (the producers of data) around Helsinki region. The third section, data sharing, is directly involved with the users of HRI's services. The shareable data can be found on HRI online database and includes a search engine to make it easier for users to find the right type of data. There is a close relationship between HRI and the users, so the feedback from users is taken into consideration to further improve the data platform. The final area is the utilization of the data. HRI is designed as such, so that the government, businesses and citizens can use the data for their own needs, for example, decision making, development of new innovations and research (Helsinki Region Infoshare, 2024b).

The most common type of datasets are maps representing various areas of Helsinki region, such as historical city maps, city plans, property maps, soil type maps, traffic routes and many other. This is followed by datasets about the population. Furthermore, there are various datasets about the constructed environment like housing, construction, buildings and similar. Finland is also known for its nature and environment preservation, thus, there are a lot of environmental datasets available. In addition to variety of open datasets available, HRI provides 327 showcases which have been developed by other organizations and users. Most showcases fall into the category of mobile applications, followed by visualisations, data journalism, different tools and city models. Within each showcase, there is a list of used datasets from HRI which helps the viewer to understand what kind of data was utilized for application or visualization development (Helsinki Region Infoshare, n.d.). Such approach enhances data transparency and promotes smart service innovation among the citizens.

3.5.2 Open data platform of the city of Kuopio

The city of Kuopio developed its own open data platform in order to maximize the utilization of different data sources in an efficient way. The officinal Finnish name of their platform is Datajalostamo Kuopio, which can be translated as either "data processing centre of Kuopio" or "data refinery Kuopio" into English language. It has been developed with a goal to provide high usability for their main users: organizations, researchers, educational institutions, welfare services and the city of Kuopio itself. Hence, this platform represents a basic smart

city digital infrastructure that offers various benefits and opportunities, such as data-driven business opportunities for local companies and improved access to data for research and educational institutions. By utilizing various data sources offered on the platform, applications are being developed, meant to enhance day-to-day life of the citizens and promote sustainable development and carbon neutrality. Moreover, looking from a data management point of view, such applications are improving data usability and accessibility in the city of Kuopio. The main purpose of their platform is to distribute and process available smart city data from numerous sources by using the API services. Currently, services offered on the Datajalostamo Kuopio platform are data storage and user management. Data storage service translates to the storage of historical data and time series, which enables improved data-driven forecasting. User management service enables appropriate level of identification, given the nature of the data which is to be produced and utilized. However, there will be more services available in the future, as they are being developed regularly (City of Kuopio, n.d.-a).

Data sources available on the platform encompass several smart city elements, such as smart mobility and smart environment. For instance, by building automatic counting point network for pedestrians and cyclists, the city of Kuopio gets real-time and accurate traffic volume data and long period time series data. Additionally, there are measurements and visualizations available about electric vehicle charging stations. Similarly, data about parking locations, number of parking spaces and parking restrictions can be seen, too. Both real-time data and long-term data are available. Lastly, during winter periods, it is especially important to have timely road maintenance, hence, the city of Kuopio offers nearly real-time data on work types and location of the contractors' machines for winter maintenance (City of Kuopio, n.d.-b).

4 OPEN DATA ECOSYSTEM IN SLOVENIA AND LJUBLJANA

4.1 Digital public infrastructure for data sharing

In order to enable public service delivery, public sector efficiency and the wider digital economy, digital public infrastructure (hereinafter: DPI) provides the basis for data exchange, system cohesion and cross-sector innovation (OECD, 2025). DPI describes a group of shared, secure and interconnected digital systems built to provide broad accessibility to both public and private services. It is composed of six elements, such as digital identity, digital post, digital payments, digital notifications, data-sharing systems and base registries. To design, implement and supervise such infrastructure, governments and city municipalities serve as the main actors. Additionally, they have to provide fundamental enablers, including interoperability and open-source frameworks, as well as metadata standards and standards for APIs. According to the OECD survey on Digital Government 2.0, for which the data was collected between November 2022 and January 2023, data-

sharing systems represent the most used elements of DPI, available in 28 out of 33 surveyed countries. This is followed by digital identities, which have been used in 24 out of 33 surveyed countries. The reason why digital identities are important and should be considered in other countries is their role in facilitating trusted and safe digital interactions, including the provision of access to public services. The adoption of public services through digital identity solutions is visible in the share of eligible populations that actively use them. For example, Nordic countries like Finland, Sweden, Norway, Denmark and Iceland, together with the Netherlands and South Korea, are the leaders in digital identity utilization, translating to more than 90% of active users within their population. Such success resulted from close collaboration with the private sector, especially banking institutions (OECD, 2025). Hence, it can be concluded that establishing strong relationships between public and private sector can enhance the accessibility of public services in a secure and trusted way.

DPI also enables effective data sharing systems. Such data sharing systems, with suitable safeguards, are important for enhancing the quality of public services and interoperability. In addition, they are vital for fostering innovation through the utilization of data-driven insights. Furthermore, data sharing systems have the potential to promote collaboration between public sector, private enterprises and civil society in co-creating services and consequently, stimulating economic growth and societal development (OECD, 2024).

Open data portals are considered as one of such infrastructures, as they represent the interfaces between the government data on the side and the users on the other side. Due to the rise of open government data, the role of public sector is not only limited to data collection but also to data publishing for the public, which increases the collaboration and transparency (Lněnička, 2015). Therefore, numerous governments and local municipalities have decided to develop their own open data portals, including Slovenian government.

4.2 Slovenian national open data portal

Slovenian national open data portal, also known as OPSI, was established by Slovenian Ministry of Public Administration, which is responsible for access to information of public importance. The Ministry of Digital Transformation is responsible for it from the technical point of view. The basis for the development of this portal was open-source software which was also used by English open data portal named data.gov.uk and the EU's open data portal, known under the name data.europa.eu. Currently, OPSI serves as a single national online point where public sector open data can be published. Some of the main drivers for its development and publication were the specific structures of publications and user-oriented approach, followed by the external influence and inspiration from other countries. Hence, OPSI was set up as a dedicated open data portal where open data datasets are accessible, together with metadata descriptions of all public sector datasets (Ministrstvo za javno upravo, n.d.).

The common goal of the team who is running the OPSI portal is to make Slovenia as a good example from practice in the area of open data and public data usage. According to their team, the term open data does not only refer to data and information publicly accessible, but also to the ones which are published in a way allowing anyone to use and share them easily. Furthermore, collaboration is supported with various stakeholders such as public sector, municipalities, non-governmental organizations, researchers, start-ups, universities and high schools all around Slovenia. Consequently, such collaboration should achieve their aim for open data to be utilised as much as possible in development of applications which will provide useful services to citizens and businesses (Ministrstvo za javno upravo, n.d.).

Data is published by all public sector bodies which is arranged by individual sectors. The data publication is organised as an editorial system where chief editors, subject editors and content editors are appointed. In addition to data from state authorities, it is also allowed for local governments (i.e., municipalities) to publish their own data. Everyone has the right to re-use freely accessible data that is published in the form of open data, either for profit or non-profit purposes. The open data which is published on the OPSI portal is subject to the open licence rule and the sole requirement for the re-use is citing the source (Ministrstvo za javno upravo, n.d.). This license is widely known as CC BY 4.0 and it supports standardisation of open access to knowledge in education, scientific research and government data. Additionally, it guarantees that content is available free of charge while enabling modifications and redistribution under the condition of appropriate attribution (Creative Commons, n.d.). Moreover, datasets and newly developed products, which occurred during the re-use process, can also be published by external stakeholders and the users of those datasets (Ministrstvo za javno upravo, n.d.).

4.3 Urban Digital Platform of the Municipality of Ljubljana

The MOL developed a Digital Development Strategy for the period between 2023 and 2027, which guides the process of digitalization with a focus on the benefits offered to citizens. The strategy contains five strategic goals: Digital City and Community, Digital City Administration and the MOL Extended Family, Digital Tools for City Management, Data Management and Digital Development Economy. In this thesis, I will focus on the fourth strategic goal (Data Management) because the number of automated processes in the city is growing, which makes city's data management more demanding than ever before. Consequently, Urban Digital Platform (UDP) is being developed, which will enable the MOL perform urban services more efficiently (Mestna občina Ljubljana, 2023a).

As one of the solutions within UDP, the MOL's open data portal will be established. One of the main reasons why open data will be published within UDP is recognized importance of open data's role in enabling more efficient and better-informed collaboration in the city management. In contrast to OPSI portal, open data solution within UDP will only provide open data related to the MOL. This will enhance open data availability and utilization within

the city itself and between city stakeholders. On the one hand, data will be opened both for the inhabitants and visitors of Ljubljana. On the other hand, there will be open data available for businesses and institutions, mainly educational ones. Moreover, with an aim to enhance the data economy and improve public awareness, an action plan for data opening has been developed. The purpose of such an action plan is to prepare appropriate and relevant measures for making data open and available. These measures include inventory, metadata descriptions, data selection and prioritization. Based on the action plan, data collections or datasets will be opened gradually. For all the open data that will be published on UDP, the open licence rule (CC BY 4.0) will apply and the only condition for open data re-use is attribution (Mestna občina Ljubljana, 2023a). Further details about the establishment of an open data portal within UDP are explained in subchapter 5.3, where I analyse the insights and perspectives of the interviewees related to the recognized need for more systematic and organized open data publication within the MOL.

5 EMPIRICAL RESEARCH

5.1 Research methodology

The empirical part of the thesis consists of quantitative analysis of open datasets, which are published on OPSI portal, and their characteristics, including qualitative analysis of the conducted interviews. The motivation for quantitative analysis of open datasets within OPSI portal comes from the work and research conducted by Umbrich et al. (2015), who developed a framework for monitoring and assessing the quality of open data portals. They have identified that risks such as low metadata and data quality influence the analysis and utilization of a dataset within the open data portal. Moreover, inaccurate descriptions of the open datasets introduce additional obstacles for their analysis and integration with other datasets. Their results contain findings about the steady growth of data, high variety across eighty-two open data portals, opinions on the data openness, availability and presence of metadata (Umbrich et al., 2015). Additionally, their assessment was powered by the Comprehensive Knowledge Archive Network (CKAN) software, which is an open-source data management system for data portals and makes data publishing, sharing and usage easier (CKAN, n.d.). Similarly, Lněnička (2015) proposed an evaluation framework for open data portals, which included different universal characteristics of open data portals and datasets within those portals. Based on this evaluation framework and proposed characteristics of datasets for evaluating open data portals, with the purpose of improving their quality, I focused on certain characteristics in my quantitative analysis, such as publishing institution, recency of published datasets and machine-readability of data file formats. Various governments, organizations and communities manage and share their datasets through CKAN software, with OPSI portal being one of them. Therefore, I have decided to use CKAN API Python library since it was the most convenient way of ensuring consistent and reproducible access to open datasets on OPSI portal and automated analysis,

while minimizing the limitations of manual downloading and filtering from the portal's interface.

As part of my qualitative research, I have decided to conduct interviews with three key professionals from the MOL's Office for Digitalization. They were used as a method for primary data collection, in order to provide a deeper understanding of past, current and historical open data utilization for smart service development and innovation in the MOL. By interviewing professionals who are responsible for the strategy, implementation of technical solutions, service innovation, development and establishment of UDP, I could identify current challenges, opportunities and outlook for open data utilization for smart service development and innovation within the MOL.

Given the nature of the topic I have been analysing, I conducted semi-structured interviews and designed interview questions with a goal to obtain in-depth insights about open data utilization in the MOL and, at the same time, give enough time and freedom for the interviewees to provide as many examples as possible and elaborate on their perspectives and experiences. In such a way, I obtained insightful data and information from experts on more complex questions that require area-specific knowledge, which could not be achieved if I had opted for a survey as a method in my research. Even though such interviews usually do not allow for a big enough sample variety, they still enable the interviewer to obtain independent insights and perspectives from the interviewees, without potential influences on the interviewees and their answers, compared to the scenario when the interview is conducted in a group setting (Adams, 2015).

All three semi-structured interviews were conducted separately in an online setting. The duration of the interviews varied between 35 and 75 minutes, which allowed me to obtain very detailed and comprehensive answers to my questions. Within such an approach, open-ended questions were asked with several follow-up questions, which encouraged interviewees to expand on their perspectives. Moreover, by asking follow-up questions, certain points were clarified, and I got a better understanding of some practices which were mentioned. Such interview methodology allowed me to capture professional insights and information from experts who are directly involved in the design and implementation of MOL's Digital Development Strategy and open data initiatives. Additionally, during these interviews, practice-based knowledge and critical opinions were provided about the potential and challenges of open data utilization in urban governance.

Each interview contains a set of key questions linked to the areas of digital strategy development, data governance, urban service development and innovation, and stakeholder engagement. The interview questions were tailored according to the reviewed literature and the Digital Development Strategy of the MOL, which ensures strong alignment between theory and practice. The complete sets of interview questions and answers can be found in Appendices 1, 2 and 3. To maintain the clarity of the analysis, each interview is divided into three or four sections, depending on the main theme to which the questions belonged to.

Table 1: Relevant information about the interviewees

Interviewee	Job position	Job description
DIG	Head of the Office for Digitalization	responsible for strategic leadership, development of Digital Development Strategy and overall establishment of the UDP
ODS	Head of open data solution implementation within the UDP	leads the design and deployment of open data portal/solution within the UDP
INN	Head of the Digital Development and Innovation Section	coordinates smart city service innovation projects, with the focus on adoption of modern technologies and innovative practices; included in the EU-led initiative for data space for smart communities

Source: Own work.

Since the focus of my research is on open data utilization within smart service development and innovation in the MOL, selection of the interviewees was strategic, with a goal to obtain the most reliable and professional answers. Hence, I sent requests for interviews to the professionals at the MOL's Office for Digitalization, and all the responses were positive. Each of the interviewees plays a crucial role in the municipality's digital development and innovation efforts, together with the establishment of a new open data portal within UDP. The first interviewee is the head of the Office for Digitalization, abbreviated to DIG, responsible for strategic leadership and overall establishment of the UDP. The second interviewee is the head of open data solution implementation within the UDP, abbreviated to ODS. The third interviewee is the head of the Digital Development and Innovation Section, abbreviated to INN, who is coordinating projects related to smart city service innovation and an EU-led initiative related to data space for smart communities. All three interviews were conducted in the Slovenian language and later translated into English. They were transcribed using an automated speech-to-text tool known as Whisper AI, which was executed through a short Python code in the Google Colab environment. After the automated transcription, all the textual outputs were reviewed manually by me and compared with the original voice recordings to correct grammatical errors and ensure higher accuracy with respect to technical expressions and terminology. The general information about the interviewees is shown in the Table 1.

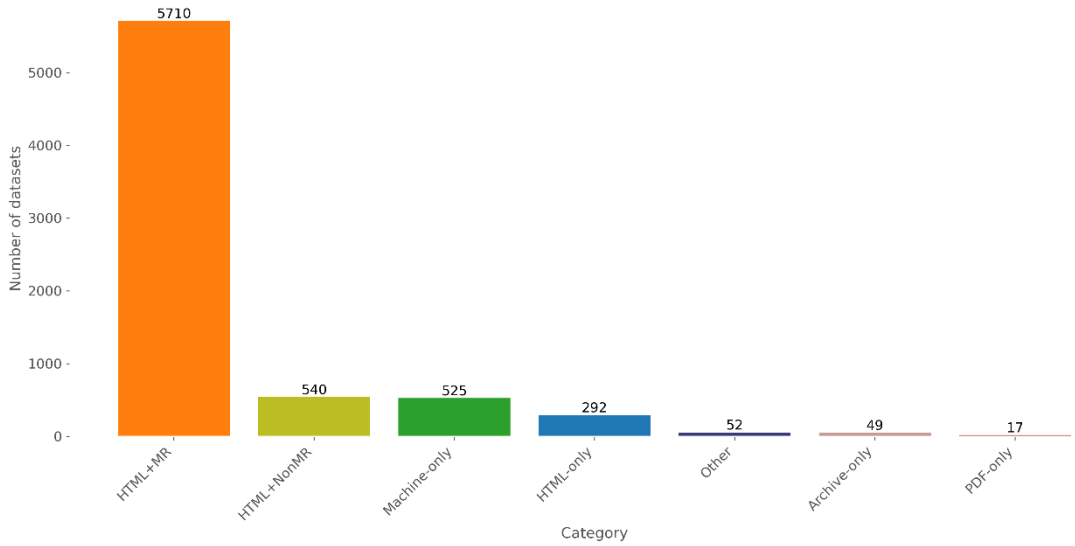
5.2 Quantitative analysis of open datasets within OPSI portal

Since OPSI portal serves as the primary source of accessing public sector open data and Slovenian municipalities are publishing their data on the same portal, I have decided to analyse current open data availability, more specifically machine readability of open data format files, data update frequency, public institutions that contributed the most in terms of open datasets publication, Ljubljana-related open datasets and which institutions published them, in order to identify opportunities for future municipal open data portal development within UDP. Hence, the analysis will be focused on several dimensions: the presence of most used data formats for publishing open data, open data update frequency between January 2023 and August 2025, distribution of datasets among the most active public institutions and municipalities. Furthermore, open datasets containing data related to the MOL were identified.

5.2.1 Formats of published open data files

According to the European Commission (2023), open data and especially HVDs, have to be available in a machine-readable format because only then do they become usable. That means open data should be automatically read and processed by computers and such formats include CSV, XLS, JSON and XML files (Open Data Handbook, n.d.). Thus, I decided to analyse what kind of file formats have been open data published in OPSI portal.

Figure 5: Formats of published open data files on OPSI portal



Source: Own work.

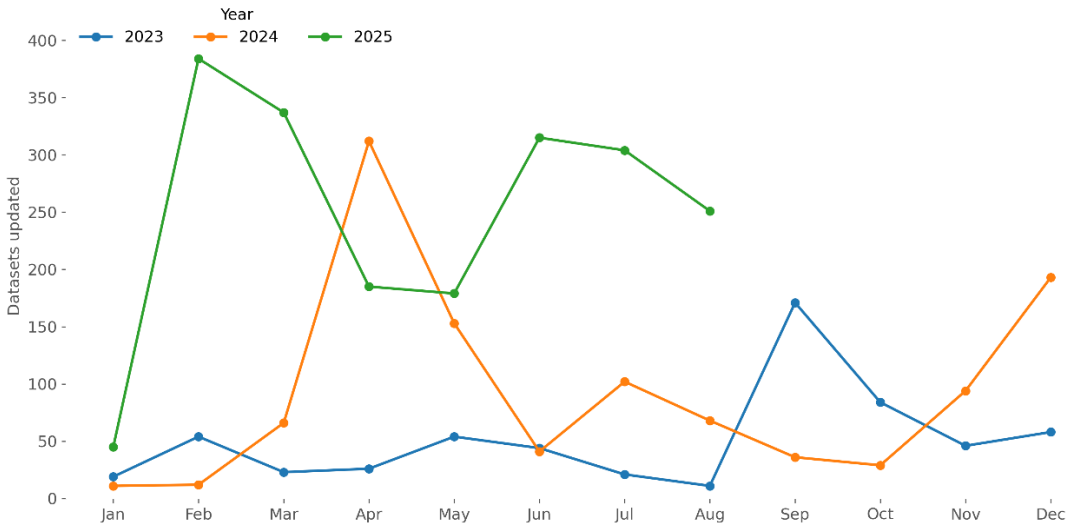
As shown in Figure 5, most open data is published both in HTML format and at least one machine-readable format, which is represented by “HTML+MR” category. This indicates efforts to ensure higher accessibility of datasets for the public, including better usability for

developers. By providing the same dataset in several machine-readable formats, apart from HTML, which is not machine-readable, innovative activities can be supported among the users. Furthermore, there is a smaller share of datasets which are published in both HTML and some other non-machine-readable format (e.g., PDF, DOC, JIF, JPEG, PPT). This is followed by datasets published in formats that are only machine-readable. Even though the number of datasets published only in HTML format is limited compared to other categories, they provide lower usability for the development of scalable services. However, this indicates that most organizations publishing their data on OPSI portal are aligned with the suggested open data practices. The "Other" category includes datasets with rare formats (e.g., MDS, KML, GML, KMZ, ODS) and hence, do not bring significant influence on the analysis. Overall, it can be concluded that there is a solid foundation for smart service development and innovation, which can be supported by available machine-readable file formats. Additionally, by lowering the amount of non-machine-readable file formats, the potential for the development of scalable and automated solutions can be increased even further.

5.2.2 Data update frequency from January 2023 to August 2025

By analysing the data update frequency from January 2023 to August 2025, as shown in Figure 6, a notable improvement can be noticed, which is particularly important for smart service development and innovation since users and developers can rely on up-to-date data.

Figure 6: Data update frequency from January 2023 to August 2025 on OPSI portal



Source: Own work.

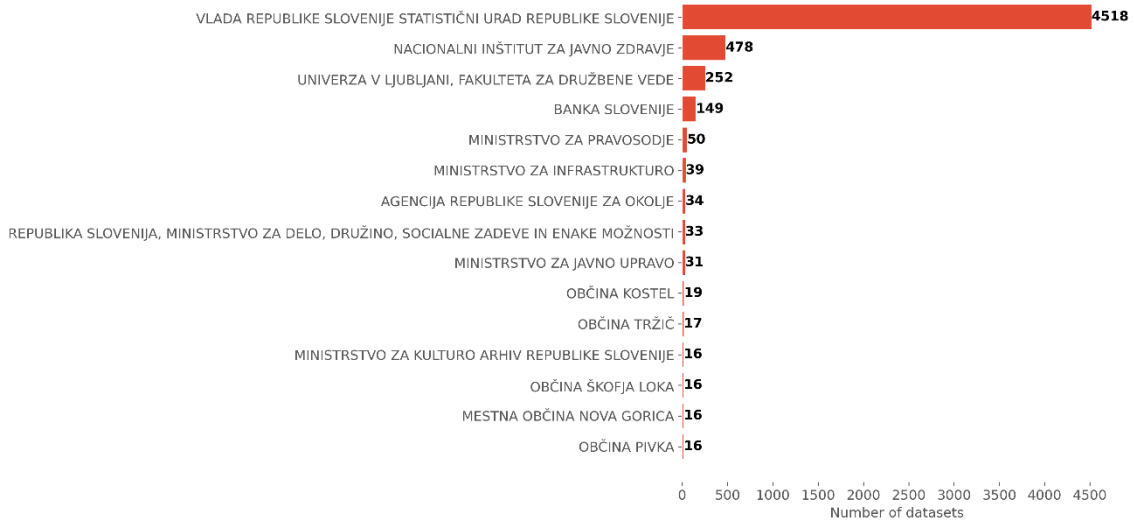
Moreover, with increased consistency of data update frequency, the reliability of the datasets is enhanced. Consistent data updates enable the development of dynamic services (e.g., live energy optimisation platforms, mobility applications) that are highly dependent on accurate

data. Additionally, policymakers who plan to utilize such data in their decision-making can compare the changes between new and outdated data or analyse the differences between two different periods, with a goal to improve the governance quality. For instance, the irregular peaks in September 2023 and April 2024 show that updates have been performed on a larger number of datasets, however, without a continuous flow. In 2025, the update frequency has been increased and distributed consistently across February, March, June and July. This could be explained by a more structured data updating process. Higher update frequency could also be explained by the increasing number of open data files being published each year. Such an increase indicates that institutions are becoming more committed to open data maintenance, which can strengthen the innovation ecosystem and better incorporate open data into public service models.

5.2.3 Public institutions with the most open data publications

As shown in Figure 7, Slovenian Statistical Office (sl. Statistični urad Republike Slovenije; hereinafter: SURS) leads in the Slovenian open data landscape, followed by National Institute for Public Health (sl. Nacionalni inštitut za javno zdravje), Faculty of Social Sciences, University of Ljubljana (sl. Fakulteta za družbene vede) and Bank of Slovenia (sl. Banka Slovenije).

Figure 7: Institutions with the most open data publications on OPSI portal



Source: Own work.

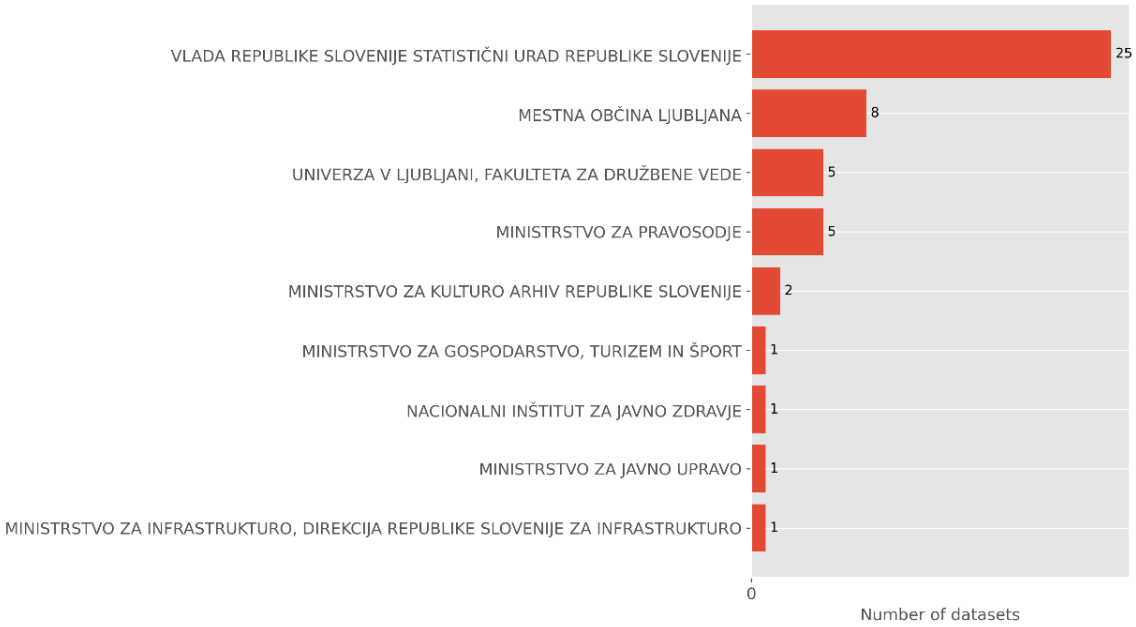
Such a distribution implies that the current open data ecosystem within Slovenian public institutions depends on a single source. Given the current availability and breadth of statistical, socioeconomic, healthcare, and financial open data, the highest potential for developing, enhancing, and innovating services currently lies within economic and health-related areas. Therefore, policymakers and developers can obtain and utilize numerous

datasets related to health, economics, statistics and finance, which increases the possibilities of creating more updated policies or developing applications that could improve people's health or well-being, for instance. Despite the limited number of municipal open datasets, this still represents an opportunity for their utilization in municipal transport planning or tourism-related applications, for instance. However, since some of the institutions dominate in the number of open data publications, there is a need for diversification of open data availability in areas other than economics and healthcare and improved efforts from Slovenian municipalities to maximise the potential of service development and innovation. Without increased and expanded contributions from the municipalities in the future, smart service development and innovation risk being narrowed only to certain areas of the country, instead of being a holistic one.

5.2.4 Institutional contributions to open data ecosystem of Ljubljana

By analysing the distribution of Ljubljana-related open datasets on OPSI portal, I wanted to understand which institutions are currently the main providers of such data, as the focus of my thesis is to provide suggestions on how smart service development and innovation in the MOL can be enhanced through open data utilization. By doing this, I got a better understanding of open data availability, reliability, diversity and potential gaps related to Ljubljana. For instance, SURS is the dominant provider of Ljubljana-related open datasets, as shown in Figure 8.

Figure 8: Distribution of Ljubljana-related open datasets on OPSI portal



Source: Own work.

This is followed by the MOL, which currently provides only a fraction of its open datasets on OPSI portal. However, according to the findings from the conducted interviews, which

will be explained in detail in the Chapter 6, the MOL is currently developing its own open data portal within UDP, which will make the MOL's open data more accessible, up-to-date and relevant for its citizens, businesses, educational institutions and other organizations. Other institutions, such as the Faculty of Social Sciences, University of Ljubljana and the Ministry of Justice (sl. Ministrstvo za pravosodje), including other Slovenian Ministries, have published a very small number of datasets, which represent sectoral contributions to the open data ecosystem. Overall, such a distribution implies there is a good potential for enhancing service development and innovation in the MOL, as they are not the only providers of their municipal-level open data, which allows for a wider range of data sources and opportunities to be utilised for improving smart city services. This potential will be strengthened even further with the publication of a new open data portal within MOL's platform UDP, currently under development.

5.3 Qualitative analysis of the interviews

For a better understanding of the open data utilization for smart service development and innovation in the MOL, it is important to analyse the perspectives and opinions of the professionals who are directly involved in the development of open data initiatives and open data publication in the MOL. Given their professional focus and expertise in areas such as strategic planning, technical implementation and innovation, they provide different perspectives on open data utilization at the municipal level.

As DIG noted, open data cannot be considered as an independent initiative but has to be incorporated into the long-term strategic planning. Hence, open data publication and utilization are at the centre of their efficient data management efforts. Under the fourth strategic pillar (Data Management), UDP will serve as an integration platform for an open data solution, which will be offered. In addition, there will be synchronization between open data publication on UDP and OPSI portal. Most of the open datasets will automatically appear on OPSI portal after being published on UDP, including their metadata and standards. Links to data sources will be provided as APIs and some of them will require user registration. For instance, when developing a new mobility app for Ljubljana, an API from UDP can be utilized to access the data about the location of the city bike stations or electric vehicle charging stations. Overall, UDP and open data portal will be designed to provide the best possible user experience. Users will be able to subscribe to notifications about various services, such as bus line detours, road closures, and water outages, so there will be no need to check different applications and websites to obtain the same information. Everything will be integrated into one platform. Moreover, it was highlighted that data-driven decision-making is essential nowadays. By giving access to data, like water usage, drought predictions and temperature levels, people can make smarter choices and utilize that data to make their households more energy efficient. However, data collection requires investments as sensors are not cheap and there needs to be a lot of them to gather accurate data. Hence, UDP is being developed as a centralized platform where such data can be managed. As per

collaboration with stakeholders, the MOL has already collaborated with start-ups present at Technology Park Ljubljana in areas such as AI and large language models. Such collaborations, together with EU-funded projects, showcase that innovation within the MOL is based on networking and partnerships with external stakeholders. DIG also stated that lately, the EU has been investing quite a lot in projects related to open data utilization, which stimulates innovation and experimentation, while enhancing the role of data-driven development of new smart services.

ODS provided practical insights on publishing and maintenance of open datasets. The specific emphasis was put on responsible and ethical open data publication, because each municipal department and organisation within MOL's wider family will be responsible for data accuracy, update frequency and metadata availability before being published on UDP. From the users' point of view, there will be anonymous and certificate-based access to the portal, which will balance data openness with security, for example, to protect APIs from unauthorized and automated requests. So far, the most used open data are orthophoto datasets (geometrically corrected aerial images) and datasets published on Geographic Information System (GIS) servers. For such datasets, the main access point was Ljubljana's old open data portal, developed with the purpose of providing geospatial data and information. Many master's theses and doctoral dissertations were written and are still being written based on such data, especially at the Faculty of Arts, Department of Geography, within the University of Ljubljana. For instance, there is research conducted about the natural process of plant and forest growth on certain hilltops in the local area, for which the MOL provided orthophoto and geospatial data. Hence, with such support, the MOL promotes and strengthens the collaboration with academic institutions. Furthermore, to support data accuracy and up-to-date application development, there will be data formats, known as shapefiles, available on the new open data portal within UDP. This means that if a data update comes on the MOL's side, the same update will be automatically incorporated in the application. Moreover, one of the successful cases of open data utilization is represented by collaboration between Slovenian citizens and a citizen from the Netherlands, who together developed open street maps of Ljubljana by using open geospatial data from the same portal. Thus, it can be concluded that there is a demand for open data publication, which results in the production of innovative applications that are used by inhabitants of Ljubljana or wider. It was also emphasized that the added value of open data comes from integrating different data sources into one that can be further upgraded to support application or service development. In the context of the MOL's service development, combining open datasets with data and information from the wider MOL family provides higher potential to create more adaptable resources for operational and innovative purposes. At the same time, ODS specified some of the challenges, such as educating staff about accurate open data publication and ensuring timely open data updates. Such insights highlight that technical data sustainability depends on organisational and human factors.

INN provided examples of how open data has already supported innovation in the MOL, especially in the areas of public transportation and environmental monitoring. The case of Ljubljana Public Transport company (LPP) demonstrates early innovation practices and transformational approaches when it comes to modern public transport application development. Namely, their story of real-time bus arrival forecast originates back to 2005, so even before smartphones existed. Back then, users could request real-time notifications about bus arrivals through Short Message Service (SMS). They had to make their data open for better fleet management, refuelling times and changing of drivers. Later in 2008, the demand for open data increased due to the introduction of smartphones. Hence, a lot of students used such data for their school projects and to develop innovative applications. However, in 2010, due to the complete openness of the system and overload of data requests, the servers went down. After two years, with the help of the Jožef Stefan Institute and one EU-funded project, the system was rebuilt and made safer and more stable. Since then, their public transportation data has been widely used by students writing their master's theses and projects at the Faculty of Electrical Engineering and the Faculty of Computer Science and Informatics in Ljubljana. Similarly, a chatbot named Troljo was developed within Facebook's Messenger and Instagram applications, which provides real-time information on bus arrivals by typing in the name of the specific bus station in Ljubljana.

In addition to the public transportation domain, open data has been utilized in the environmental domain. For instance, INN gave an example of a project DEAS, which has the purpose of identifying open data to be used for the development of effective services and acquiring new data through sensor technology. This project enabled the establishment of a comprehensive system for monitoring and analysing water levels, with a more accurate map of flood risk in the MOL. Through such an example, it is highlighted how open data can directly improve public safety. INN mentioned another example from the 2019 start-up hackathon, which illustrates how municipal data can support entrepreneurial activities and service innovation. The start-up made a predictive application which identifies areas in the MOL where you have the highest possibility of getting a parking fine, given a specific time of the day or week. These examples demonstrate open data's role in providing new services, supporting research and entrepreneurship, while focusing on the specific needs of the citizens.

6 RESEARCH DISCUSSION

6.1 Key findings

Within this subchapter, I present the key findings from the semi-structured interviews with professionals from the MOL's Office for Digitalization, complemented by the insights from the quantitative analysis of OPSI portal. The findings are represented in a table format, which provides a clear and systematic overview of the key themes and implications for the service

development and innovation, rather than a narrative one. Overall, the interviews revealed that open data within the MOL has been utilized for smart service development and innovation.

Table 2: Summary of the key research findings

Category	Finding	Implication for smart service development and innovation
Governance and strategy	The UDP will embed open data as a core municipal platform function.	Enables better integration of datasets with transactional services, which improves service development and fosters innovation within different domains.
Data management and quality	Presence of metadata, data formats and validations require efforts and capacity.	Provides high-quality data inputs for development of reliable services and supports innovative application development by the developers.
Access and security	Tiered platform access (anonymous or digital certificate) balances openness with platform stability and safety.	Through stable APIs, sustainable service development and innovation is supported, especially when it comes to commercial-grade services.
Innovation mechanisms	Hackathons and collaborations with start-ups translate open data into innovative applications and solutions.	Prototyping supports service development and innovation is driven by converting raw data into new products and services.
Value creation	Real-time and historical public transportation data build citizen-oriented applications, while sensor data improves risk mitigation and improves citizens' well-being.	Development and innovation of predictive public mobility services is stimulated, together with the timely risk-management by utilizing sensor data and personalized alert systems.
Ecosystem and partnerships	Collaboration with the faculties within the University of Ljubljana adds value.	Academia and industry collaboration supports service development co-creation and increases innovation.
Standards and interoperability	European interoperability and standards enable more sustainable and future-oriented open data publishing.	Scalable service development and innovation across different cities is promoted.

Source: Own work.

Development of UDP serves as an excellent example where open data utilization efforts will be achieved through the offer of new types of services and possibilities of subscribing to personalized notifications about live traffic data, road closures, public transportation reroutes, disruptions in the supply of electricity, water and many others. Secondly, within organized events, such as hackathons, and long-established collaborations with different faculties at the University of Ljubljana and start-up communities. Thirdly, by both international and domestic citizens in the application development, who have innovative ideas of how certain services can be improved. However, certain challenges still exist, mainly related to data privacy restrictions, staff training and data governance.

Insights from the qualitative research are accompanied by quantitative insights from OPSI open data portal analysis. For instance, most datasets are published in machine-readable formats, usually together with a non-machine-readable format, which implies an improved accessibility of the data. Data frequency updates have become more common and consistent, which enables the development and innovation of services based on reliable and up-to-date data. With regard to the institutional contributions to the publication of open datasets that refer to the MOL, it can be implied that there is a good potential for enhancing service development and innovation in the MOL, as they are not the sole providers of their municipal-level open data. For instance, the Slovenian Statistical Office (SURS) has contributed the most to the open data ecosystem within the MOL until now. However, these contributions to the open data ecosystem will be changed with the publication of the UDP and open data portal within it, when accessibility is expected to be enhanced, together with the increased number of citizen-oriented smart services. These findings and their implications for the smart service development and innovation were explained in more detail in the subchapters 5.2.1, 5.2.2, 5.2.3 and 5.2.4. Therefore, in this subchapter, I decided to focus on a more detailed explanation of the key findings from the qualitative analysis of the interviews, with their implications for smart service development and innovation, which are shown in Table 2.

6.2 Theoretical and practical implications

From a strategic point of view, open data in the MOL is embedded in the Digital Development Strategy from 2023 to 2027, within which UDP will represent the central integration tool. As DIG explained, before establishing the strategy, internal reorganization happened, which elevated their visibility and importance among other municipal departments: “With the establishment of a new organizational structure, we laid the foundation to start addressing digital transformation”. Additionally, DIG emphasized during the interview that external and internal stakeholders were included in the strategy development process, including workshops and meetings with municipal and city councillors, when goals were presented to them, an approach supported by the research of Berntzen and Johannessen (2015). Moreover, focus groups with citizens are being held to evaluate specific features of the UDP, as such a user feedback cycle will help them improve

the services which are currently offered in the MOL, which is the crucial step in the testing phase before the platform will be published. Such focus group discussions between professionals and citizens were recognized by Simonofski et al. (2019) as one of the successful approaches for gathering innovative ideas and recognizing citizens' requirements. As per user experience point of view, digital public platforms are meant to be easy to access, with user-friendly interface and established data security standards (Anthony Jnr, 2024). This research finding is acknowledged by DIG who stated: "Because the goal is to help users find the data they need as quickly as possible" and "…that is why we must take care of the safety and reliability of the published data".

The literature emphasizes the role of open data as one of the most effective resources for improving smart city elements such as environment, mobility, economy, government and people (Ojo et al., 2015). This view was highlighted by INN, who provided examples of open data utilization for application development within public transportation and the environmental domain. The examples included the case of Ljubljana Public Transportation (LPP) and chatbot Troljo, while DEAS project highlights environmental monitoring efforts for more precise prediction of high-water levels and avoiding flood threats in the MOL. These three examples show how open innovation can improve service efficiency, citizen well-being and environmental sustainability, as referenced in previous research conducted by Yigitcanlar and Teriman (2014), who stated the goal of sustainable city development is to improve the quality of life of the city's inhabitants through sustainability-oriented innovations.

During the interviews with DIG and INN, another finding was confirmed from previous literature, which describes how digital public platforms are promoting educational initiatives through brainstorming sessions, using the open data in development of citizen-focused applications, programming introductions and competitions, such as hackathons (Simonofski et al., 2017). The MOL has recognized the benefits of participating in start-up hackathons and providing its open data for such purposes, depicted by the example of the 2019 start-up hackathon, when an interesting application was developed, which calculated and showed the statistical probability of getting a parking ticket given the time and location within the MOL. Furthermore, collaboration with start-ups is maintained through Technology Park Ljubljana.

When it comes to challenges faced with open data publication and smart city project development, all the interviewees mentioned three categories of challenges: legal or privacy constraints, organisational requirements and sustainability of resources. Namely, privacy regulations and legal data ownership impose significant obstacles on what kind of data is suitable for releasing as open data, which represent challenges identified by Conradie and Choenni (2014). INN provided an example of such obstacles, depicted by the case of once open datasets about newly registered electric vehicles by month, which used to be available on OPSI portal in the past. Such data helped the MOL determine the trends and needs for the electric stations' charging network. However, the Ministry of Infrastructure, which is the owner and publisher of such data, had to remove them from OPSI portal as personal data

was identified within the datasets. Similarly, both DIG and INN emphasized the need for robustness of organisational frameworks for open data, such as standardized metadata, data catalogues and registers. Additionally, ODS believes that staff training on accurate open data publication and timely updates represents additional challenges. Namely, ODS explained that the beginning will be difficult, as the staff of other entities within the MOL group must be trained and educated on how to publish and update the datasets properly and regularly, depending on the data type. This means that the presence of modern technical infrastructure is not enough for a successful open data project. This goes in line with the statement by DIG: "You need the right people, knowledge and technology. If the municipality does not have that, the project simply will not work". On the other hand, the interviews did not identify the presence of the challenges mentioned by Heimstädt (2017), such as decoupling by information bending and orchestration. Therefore, it can be concluded that the open data publication within UDP will follow the data transparency demands with a responsible and comprehensive approach to open data management.

Moreover, INN pointed out that obstacles to reaching a coherent open data ecosystem in the city environment lie in private businesses' reluctance to make their data open. Unlike the public sector, private businesses are profit-oriented and want to keep their competitive advantage; hence, they do not want to make their data available for re-use without clear authorship, without control or without payment. Similar challenges have already been referenced in the previous literature, for instance, in Ma and Lam (2019), who recognized the lack of incentives for the private sector to share its data. Together, such obstacles and challenges highlight that city service development and open data initiatives need continuous investment and governance alignment.

One of the key opportunities for further development of open data initiatives in the MOL lies within EU-wide action for making a data space for smart communities that will, according to INN, guide the future development of the open data portal within UDP. The MOL is already part of this initiative and will strive to deliver the best services to its inhabitants by enabling interoperability to achieve critical goals, as defined in the mission (European data space for smart communities, n.d.). Such a data space will introduce better data governance, interoperability, secure access and even payment systems, which will motivate private businesses to publish their data, which will strengthen the role of the private sector in cross-sectoral data sharing and collaboration. Such an initiative would not only improve open data initiatives but also enable new opportunities for innovation between city stakeholders within a trusted framework.

6.3 Limitations and future research opportunities

Since the open data portal within UDP is currently under development and it is expected to be made available by the end of this year according to DIG, the empirical research lacks the diversity of opinions from other external stakeholders and citizens on the open data portal

usability, open data accessibility and other functionalities of the portal, which would have enriched the key findings with variety of perspectives from these stakeholders. However, the interviewed professionals from the MOL's Office for Digitalization emphasized that both external and internal stakeholders have been involved in the strategy development and development of the services within the UDP platform. Hence, the thesis represents findings based on collaborative efforts to develop the UDP platform and open data portal within it, which will focus on the users' needs and consequently, support the development of smart services and innovations within the municipality of Ljubljana.

Regarding future research opportunities, there are several suggestions I would like to provide. After the UDP open data portal is published and used in practice, future research could investigate how the open data from the new portal has been used, by whom and for which purposes. Furthermore, concrete outcomes of the future open data utilization within the MOL should be examined and whether they have resulted in achieving enhanced sustainability efforts for carbon neutrality, which is one of the main priorities of the Mission 100 Climate Neutral and Smart Cities 2030. Moreover, future research could also examine if the new services to be offered on the UDP platform have improved the user engagement and if the open data solutions have resulted in achieving data management goals as part of the MOL's Digital Development Strategy. Future research efforts should be aimed at exploring how diversification of open data providers, both at the municipal and national levels, could improve service development and innovation. As mentioned by INN during the interview, the European data space for smart communities represents one of the key opportunities for further development of open data initiatives within the Municipality of Ljubljana. Therefore, future research should analyse whether such data space has improved data governance, interoperability and cross-sectoral data sharing between the public and private sector. Lastly, comparative analysis with other cities within the EU could be utilized for highlighting the role of interoperability for enhancing smart city services and the best practices of open data utilization.

7 CONCLUSION

In my master's thesis, I analysed the role of open data and related initiatives in the development and innovation of smart services in the MOL. Thus, I firstly analysed the Slovenian national open data portal, as it currently represents the primary access point for obtaining public sector data. The reason I decided to analyse the diversity of open data availability, open data format files, data update frequency, publishing public institutions and their contributions to open data ecosystem in the MOL, was to assess what open data are currently available and utilized by its users and what are the potential gaps within open data availability that could be overcome in the future and opportunities leveraged. Secondly, I conducted three semi-structured interviews with key professionals from the MOL's Office for Digitalization. This way, I gained in-depth information and a better understanding of the

past, current and future open data utilization for smart service development and innovation in the MOL.

The purpose of the master's thesis was to show how open data, its utilization and open data initiatives can improve smart city services and enhance innovation in the MOL, so that the sustainability in the city is enhanced, the well-being of its inhabitants is improved, and a transition towards a more efficient, inclusive and climate-resilient urban environment is supported. Additionally, I wanted to answer the following research question: "How can open data enhance smart city services and foster innovation in the Municipality of Ljubljana?".

In terms of the key findings of my empirical research, I have found that open data, when properly integrated into smart urban development and frequently updated, can make a positive impact on the smart service development and innovation in the MOL. Analysis of the interviews showed that the MOL's Office for Digitalization is actively investing its resources to achieve the goals of its Digital Development Strategy. Lately, they have been investing their knowledge, time and effort into establishing the Urban Digital Platform, within which the open data portal of the MOL will be available. This shows that the benefits and value of the open data availability and utilization have been recognized within the municipality. As open data from the MOL has already been utilized by developers, start-ups, citizens, both domestic and foreign, and students, the publication of the MOL's new open data portal will enhance even further the opportunities for collaboration, development and innovation of data-driven smart services. Given the presence of certain challenges, such as data privacy restrictions and data governance complexity, I concluded that opportunities for further development lie in improved data governance, cross-sector collaboration and the European data space for smart communities.

LIST OF KEY LITERATURE

1. Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of urban technology*, *22*(1), 3-21. https://doi.org/10.1080/10630732.2014.942092
2. Berrone, P., Ricart, J. E., & Carrasco, C. (2016). The open kimono: Toward a general framework for open data initiatives in cities. *California Management Review*, *59*(1), 39-70. https://doi.org/10.1177/0008125616683703
3. Gassmann, O., Böhm, J., & Palmié, M. (2019). *Smart cities: Introducing Digital Innovation to Cities*. Emerald Publishing Limited. http://dx.doi.org/10.1108/9781787696136
4. Neves, F. T., de Castro Neto, M., & Aparicio, M. (2020). The impacts of open data initiatives on smart cities: A framework for evaluation and monitoring. *Cities*, *106*, 102860. https://doi.org/10.1016/j.cities.2020.102860
5. Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017). Delivering public value through open government data initiatives in a Smart City context. *Information systems frontiers*, *19*(2), 213-229. https://doi.org/10.1007/s10796-016-9673-7

REFERENCE LIST

1. Abella, A., Ortiz-de-Urbina-Criado, M., & De-Pablos-Heredero, C. (2017). A model for the analysis of data-driven innovation and value generation in smart cities' ecosystems. *Cities*, *64*, 47-53. https://doi.org/10.1016/j.cities.2017.01.011
2. Adams, W. C. (2015). Conducting Semi-Structured Interviews. In K. E. Newcomer, H. P. Hatry, & J. S. Wholey (Eds.), *Handbook of practical program evaluation* (4th ed., pp. 492-505). Wiley. https://doi.org/10.1002/9781119171386.ch19
3. Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). Sustainability-oriented innovation: A systematic review. *International Journal of Management Reviews*, *18*(2), 180-205. https://doi.org/10.1111/ijmr.12068
4. Aguilera, U., Peña, O., Belmonte, O., & López-de-Ipiña, D. (2017). Citizen-centric data services for smarter cities. *Future Generation Computer Systems*, *76*, 234-247. https://doi.org/10.1016/j.future.2016.10.031
5. Ahlgren, B., Hidell, M., & Ngai, E. C. H. (2016). Internet of things for smart cities: Interoperability and open data. *IEEE Internet Computing*, *20*(6), 52-56. https://doi.org/10.1109/MIC.2016.124
6. Akterujjaman, S. M., Mulder, R., & Kievit, H. (2022). The influence of strategic orientation on co-creation in smart city projects: Enjoy the benefits of

collaboration. *International Journal of Construction Management, 22*(9), 1597-1605. https://doi.org/10.1080/15623599.2020.1736834

7. Anthony Jnr, B. (2021). Exploring data driven initiatives for smart city development: empirical evidence from techno-stakeholders' perspective. *Urban Research & Practice, 15*(4), 529–560. https://doi.org/10.1080/17535069.2020.1869816
8. Anthony Jnr, B. (2024). The role of community engagement in urban innovation towards the co-creation of smart sustainable cities. *Journal of the Knowledge Economy, 15*(1), 1592-1624. https://doi.org/10.1007/s13132-023-01176-1
9. Anthopoulos, L. G. (2015). Understanding the Smart City Domain: A literature review. In M. Rodríguez-Bolívar (Ed.), *Transforming city governments for successful smart cities* (pp. 9-21). Springer. http://dx.doi.org/10.1007/978-3-319-03167-5_2
10. Axelsson, K., & Granath, M. (2018). Stakeholders' stake and relation to smartness in smart city development: Insights from a Swedish city planning project. *Government Information Quarterly, 35*(4), 693-702. https://doi.org/10.1016/j.giq.2018.09.001
11. Bang, H. (2005). Among everyday makers and expert citizens. In *Remaking governance* (pp. 159-178). Policy Press. https://doi.org/10.51952/9781847421388.ch008
12. Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., Ouzounis, G., & Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics, 214*(1), 481-518. https://doi.org/10.1140/epjst/e2012-01703-3
13. Berends, J., Carrara, W., & Radu, C. (2020). *Analytical report 9: The Economic Benefits of Open Data*. Publications Office of the European Union. https://doi.org/10.2830/081754
14. Berntzen, L., & Johannessen, M. R. (2015). The role of citizen participation in municipal smart city projects: Lessons learned from Norway. In *Smarter as the new urban agenda: A comprehensive view of the 21st century city* (pp. 299-314). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-17620-8_16
15. Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable cities and society, 31*, 183-212. https://doi.org/10.1016/j.scs.2017.02.016
16. Bommert, B. (2010). Collaborative innovation in the public sector. *International public management review, 11*(1), 15-33. https://ipmr.net/index.php/ipmr/article/view/73
17. Bovaird, T., & Loeffler, E. (2012). From Engagement to Co-production: The Contribution of Users and Communities to Outcomes and Public Value. *Voluntas: international journal of voluntary and nonprofit organizations, 23*(4), 1119-1138. https://doi.org/10.1007/s11266-012-9309-6
18. Cahn, E. S., & Gray, C. (2013). Co-production from a normative perspective. In *New public governance, the third sector, and co-production* (pp. 129-144). Routledge.
19. Capdevila, I., & Zarlenga, M. I. (2015). Smart city or smart citizens? The Barcelona case. *Journal of strategy and management, 8*(3), 266-282. https://doi.org/10.1108/JSMA-03-2015-0030

20. Capra, C. F. (2019). The Smart City and Its Citizens: Governance and Citizen Participation in Amsterdam Smart City. In *Smart Cities and Smart Spaces: Concepts, Methodologies, Tools, and Applications* (pp. 1407-1427). IGI Global Scientific Publishing. http://dx.doi.org/10.4018/978-1-5225-7030-1.ch063
21. Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart Cities in Europe. *Journal of Urban Technology, 18*(2), 65–82. https://doi.org/10.1080/10630732.2011.601117
22. Caragliu, A., de Dominicis, L., & de Groot, H. L. (2016). Both Marshall and Jacobs were right!. *Economic geography*, *92*(1), 87-111. https://doi.org/10.1080/00130095.2015.1094371
23. Chen, J. S., Tsou, H. T., & Ching, R. K. (2011). Co-production and its effects on service innovation. *Industrial Marketing Management*, *40*(8), 1331-1346. https://doi.org/10.1016/j.indmarman.2011.03.001
24. Chesbrough, H. (2011). *Open Services Innovation: Rethinking Your Business to Compete and Grow in a New Era*. John Wiley & Sons. http://dx.doi.org/10.1007/978-88-470-1980-5
25. City of Kuopio. (n.d.-a). *Info*. Datajalostamo Kuopio. https://www.datajalostamo.fi/#/info
26. City of Kuopio. (n.d.-b). *Data sources*. Datajalostamo Kuopio. https://www.datajalostamo.fi/#/interfaces
27. City of Ljubljana. (n.d.). Ljubljana on the path to climate neutral future. https://www.ljubljana.si/en/ljubljana-for-you/ljubljana-on-the-path-to-climate-neutral-future/
28. CKAN. (n.d.). *The world's leading open source data management system*. CKAN. https://ckan.org/
29. Clarke, R., Heitlinger, S., Light, A., Forlano, L., Foth, M., & DiSalvo, C. (2019). More-than-human participation: Design for sustainable smart city futures. *Interactions*, *26*(3), 60-63. https://doi.org/10.1145/3319075
30. Conradie, P., & Choenni, S. (2014). On the barriers for local government releasing open data. *Government information quarterly*, *31*, S10-S17. https://doi.org/10.1016/j.giq.2014.01.003
31. Creative Commons. (n.d.). *Creative Commons Attribution 4.0 International (CC BY 4.0)*. https://creativecommons.org/licenses/by/4.0/
32. Dameri, R. P., & Cocchia, A. (2013). Smart city and digital city: twenty years of terminology evolution. In *X Conference of the Italian Chapter of AIS, ITAIS* (Vol. 1, No. 8).
33. Davies, T., & Perini, F. (2016). Researching the emerging impacts of open data: revisiting the ODDC conceptual framework. *The Journal of Community Informatics, 12*(2). https://doi.org/10.15353/joci.v12i2.3246
34. Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information. *Official Journal of the European Union*, L 172, 56–83.

35. European Commission. (2016, January 25). *Commission presents its evaluation of the 7th Framework Programme for Research* [Fact sheet]. https://ec.europa.eu/commission/presscorner/api/files/document/print/en/memo_16_146/MEMO_16_146_EN.pdf
36. European Commission. (2023, January 20). *Commission defines high-value datasets to be made available for re-use* [Press release]. Shaping Europe's digital future. https://digital-strategy.ec.europa.eu/en/news/commission-defines-high-value-datasets-be-made-available-re-use
37. European Commission. (2024a, October 10). *European Data Governance Act*. Shaping Europe's Digital Future. https://digital-strategy.ec.europa.eu/en/policies/data-governance-act
38. European Commission. (2024b). Ethics guidelines for trustworthy AI. In *Shaping Europe's Digital Future*. https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai
39. European Commission. (2025a, April 9). *A European strategy for data*. Shaping Europe's Digital Future. https://digital-strategy.ec.europa.eu/en/policies/strategy-data
40. European Commission. (2025b, June 17). Open data. Shaping Europe's Digital Future. https://digital-strategy.ec.europa.eu/en/policies/open-data
41. European Commission. (2025c). *European legislation on open data*. Shaping Europe's Digital Future. https://digital-strategy.ec.europa.eu/en/policies/legislation-open-data
42. European Commission. (n.d.-a). *Smart cities*. EU Regional and Urban Development. https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en
43. European Commission. (n.d.-b). *European innovation ecosystems*. Research and Innovation. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/european-innovation-ecosystems_en
44. European data space for smart communities. (n.d.). *Shape Europe's Green and Digital Future: European data space for smart communities*. European Data Space for Smart Communities. https://www.ds4sscc.eu/
45. European Union. (2023, July 28). Creating smart cities with open data. *data.europa.eu*. https://data.europa.eu/en/news-events/news/creating-smart-cities-open-data
46. European Union. (2024, April 10). *Striking a balance: Open data and privacy in the digital era*. data.europa.eu. https://data.europa.eu/en/news-events/news/striking-balance-open-data-and-privacy-digital-era
47. European Union. (2025, April 9). *Smart Cities: Integrating AI and open data.* data.europa.eu. https://data.europa.eu/en/news-events/news/smart-cities-integrating-ai-and-open-data
48. European Union. (n.d.). *What is open data*. data.europa.eu. https://data.europa.eu/en/dataeuropa-academy/what-open-data
49. Fredericks, J., Tomitsch, M., & Haeusler, M. H. (2020). Redefining community engagement in smart cities: design patterns for a smart engagement ecosystem.

In *Citizen-Responsive Urban E-Planning: Recent Developments and Critical Perspectives* (pp. 13-53). IGI Global. http://dx.doi.org/10.4018/978-1-7998-4018-3.ch002

50. Gabrys, J. (2014). Programming environments: Environmentality and citizen sensing in the smart city. *Environment and planning D: Society and space*, *32*(1), 30-48. https://doi.org/10.1068/d16812
51. Gartner. (n.d.). *Digitalization*. Gartner Glossary. https://www.gartner.com/en/information-technology/glossary/digitalization
52. Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. J. (2007). *Smart cities - Ranking of European medium-sized cities.* Centre of Regional Science, Vienna University of Technology.
53. Goldsmith, S., & Crawford, S. (2014). *The responsive city: Engaging communities through data-smart governance*. John Wiley & Sons.
54. Goodman, J., Korsunova, A., & Halme, M. (2017). Our collaborative future: Activities and roles of stakeholders in sustainability-oriented innovation. *Business Strategy and the environment*, *26*(6), 731-753. https://doi.org/10.1002/bse.1941
55. Goodwin, M. (2024, April 9). *What is an API (application programming interface)?* IBM. https://www.ibm.com/think/topics/api
56. Granier, B., & Kudo, H. (2016). How are citizens involved in smart cities? Analysing citizen participation in Japanese "Smart Communities". *Information Polity*, *21*(1), 61-76. https://doi.org/10.3233/IP-150367
57. Gray, J., & Rumpe, B. (2015). Models for digitalization. *Software & Systems Modeling*, *14*(4), 1319-1320. https://doi.org/10.1007/s10270-015-0494-9
58. Guo, Q., Wang, Y., & Dong, X. (2022). Effects of smart city construction on energy saving and CO2 emission reduction: Evidence from China. *Applied Energy*, *313*, 118879. https://doi.org/10.1016/j.apenergy.2022.118879
59. Gupta, A., Panagiotopoulos, P., & Bowen, F. (2020). An orchestration approach to smart city data ecosystems. *Technological Forecasting and Social Change*, *153*, 119929. https://doi.org/10.1016/j.techfore.2020.119929
60. Gutiérrez, V., Amaxilatis, D., Mylonas, G., & Munoz, L. (2017). Empowering citizens toward the co-creation of sustainable cities. *IEEE Internet of Things Journal*, *5*(2), 668-676. https://doi.org/10.1109/JIOT.2017.2743783
61. Hansen, E. G., & Grosse-Dunker, F. (2013). Sustainability-oriented innovation. In *Encyclopedia of corporate social responsibility* (pp. 2407-2417). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-28036-8_552
62. Hartley, J., Sørensen, E., & Torfing, J. (2013). Collaborative innovation: A viable alternative to market competition and organizational entrepreneurship. *Public administration review*, *73*(6), 821-830. https://doi.org/10.1111/puar.12136
63. Haustein, E., & Lorson, P. C. (2023). Co-creation and co-production in municipal risk governance–A case study of citizen participation in a German city. *Public Management Review*, *25*(2), 376-403. https://doi.org/10.1080/14719037.2021.1972704

64. Heimstädt, M. (2017). Openwashing: A decoupling perspective on organizational transparency. *Technological forecasting and social change*, *125*, 77-86. https://doi.org/10.1016/j.techfore.2017.03.037
65. Helsinki Region Infoshare. (2024a, April). *What is HRI?* Helsinki Region Infoshare. https://hri.fi/en_gb/hri-service/what-is-hri/
66. Helsinki Region Infoshare. (2024b, April). *Operational areas.* Helsinki Region Infoshare. https://hri.fi/en_gb/hri-service/what-is-hri/operational-areas/
67. Helsinki Region Infoshare. (n.d.). *Showcases*. Helsinki Region Infoshare. https://hri.fi/data/en_GB/showcase
68. Hilgers, D., & Ihl, C. (2010). Citizensourcing: Applying the concept of open innovation to the public sector. *International Journal of Public Participation*, *4*(1).
69. International Energy Agency. (2024). *Empowering Urban Energy Transitions: Smart cities and smart grids*. https://www.iea.org/reports/empowering-urban-energy-transitions/executive-summary
70. Ismagilova, E., Hughes, L., Dwivedi, Y. K., & Raman, K. R. (2019). Smart cities: Advances in research—An information systems perspective. *International journal of information management*, *47*, 88-100. https://doi.org/10.1016/j.ijinfomgt.2019.01.004
71. Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data and open government. *Information systems management*, *29*(4), 258-268. https://doi.org/10.1080/10580530.2012.716740
72. Jucevičius, R., Patašienė, I., & Patašius, M. (2014). Digital dimension of smart city: critical analysis. *Procedia-Social and Behavioral Sciences*, *156*, 146-150. https://doi.org/10.1016/j.sbspro.2014.11.137
73. Jussila, J., Lehtonen, T., Sillanpää, V., Helander, N., & Kallio, J. (2016). Can e-government solutions enhance the work in municipalities? Empirical evidence from case Lupapiste. In *Proceedings of the 20th International Academic Mindtrek Conference* (pp. 20-25). https://doi.org/10.1145/2994310.2994357
74. Karadimitriou, N., Magnani, G., Timmerman, R., Marshall, S., & Hudson-Smith, A. (2022). Designing an incubator of public spaces platform: Applying cybernetic principles to the co-creation of spaces. *Land Use Policy*, *119*, 106187. https://doi.org/10.1016/j.landusepol.2022.106187
75. Khatoun, R., & Zeadally, S. (2016). Smart cities: concepts, architectures, research opportunities. *Communications of the ACM*, *59*(8), 46-57. https://doi.org/10.1145/2858789
76. Klewitz, J., & Hansen, E. G. (2014). Sustainability-oriented innovation of SMEs: a systematic review. *Journal of cleaner production*, *65*, 57-75. https://doi.org/10.1016/j.jclepro.2013.07.017
77. Kloppers, J. (2016, May). Citizen engagement in Cape Town's transition towards a smart city. In *2016 IST-Africa Week Conference* (pp. 1-13). IEEE. https://doi.org/10.1109/ISTAFRICA.2016.7530614

78. Komninos, N. (2011). Intelligent cities: Variable geometries of spatial intelligence. *Intelligent Buildings International*, *3*(3), 172-188. https://doi.org/10.1080/17508975.2011.579339
79. Kumar, T. M. V. (2020). *Smart Living for Smart Cities: Community Study, Ways and Means*. Springer.
80. Kummitha, R. K. R., & Crutzen, N. (2019). Smart cities and the citizen-driven internet of things: A qualitative inquiry into an emerging smart city. *Technological Forecasting and Social Change*, *140*, 44-53. https://doi.org/10.1016/j.techfore.2018.12.001
81. Kundra, V. (2012). *Digital fuel of the 21st century: Innovation through open data and the network effect*. Shorenstein Center Discussion Paper Series. Harvard University.
82. Larios, V. M., Gomez, L., Mora, O. B., Maciel, R., & Villanueva-Rosales, N. (2016). Living labs for smart cities: A use case in Guadalajara city to foster innovation and develop citizen-centered solutions. In *2016 IEEE International Smart Cities Conference (ISC2)* (pp. 1-6). IEEE. https://doi.org/10.1109/ISC2.2016.7580773
83. Leclercq, E. M., & Rijshouwer, E. A. (2022). Enabling citizens' Right to the Smart City through the co-creation of digital platforms. *Urban Transformations*, *4*(1), 2. https://doi.org/10.1186/s42854-022-00030-y
84. Li, N., R, P., & Padwal, H. H. (2020). The importance of public support in the implementation of green transportation in smart cities using smart vehicle bicycle communication transport. *The Electronic Library*, *38*(5/6), 997-1011. https://doi.org/10.1108/EL-07-2020-0210
85. Lim, C., Kim, K. J., & Maglio, P. P. (2018). Smart cities with big data: Reference models, challenges, and considerations. *Cities*, *82*, 86-99. https://doi.org/10.1016/j.cities.2018.04.011
86. Lněnička, M. (2015). An in-depth analysis of open data portals as an emerging public e-service. *International Journal of Social, Education, Economics and Management Engineering*, *9*(2), 589-599.
87. Ma, R., & Lam, P. T. (2019). Investigating the barriers faced by stakeholders in open data development: A study on Hong Kong as a "smart city". *Cities*, *92*, 36-46. https://doi.org/10.1016/j.cities.2019.03.009
88. Mahajan, S., Luo, C. H., Wu, D. Y., & Chen, L. J. (2021). From Do-It-Yourself (DIY) to Do-It-Together (DIT): Reflections on designing a citizen-driven air quality monitoring framework in Taiwan. *Sustainable Cities and Society*, *66*, 102628. https://doi.org/10.1016/j.scs.2020.102628
89. Manville, C., Cochrane, G., Cave, J., Millard, J., Pederson, J. K., Thaarup, R. K., Liebe, A., Wissner, M., Massink, R., & Kotterink, B. (2014). *Mapping smart cities in the EU* (Study No. PE 507.480). European Parliament, Directorate-General for Internal Policies. https://op.europa.eu/en/publication-detail/-/publication/78882e80-fc4a-4a86-9c39-2ad88ab89f9b/language-en
90. Marsal-Llacuna, M. L., Colomer-Llinàs, J., & Meléndez-Frigola, J. (2015). Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart

Cities initiative. *Technological Forecasting and Social Change, 90*, 611-622. https://doi.org/10.1016/j.techfore.2014.01.012

91. Mestna občina Ljubljana. (2023a). Strategija digitalnega razvoja MOL [Digital Development Strategy of the Municipality of Ljubljana]. https://digitalna.ljubljana.si/assets/Strategija_digitalnega_razvoja_MOL_publikacija_WEB_0124.pdf
92. Mestna občina Ljubljana. (2023b, June 23). *Pokosili bomo, ko se bodo čebele najedle*. https://www.ljubljana.si/sl/aktualno/pokosili-bomo-ko-se-bodo-cebele-najedle-3/
93. Mestna občina Ljubljana. (2024, October 9). Ljubljana je prejela naziv Podnebno nevtralno in pametno mesto. Mestna Občina Ljubljana. https://www.ljubljana.si/sl/aktualno/ljubljana-je-prejela-naziv-podnebno-nevtralno-in-pametno-mesto/
94. Mestna občina Ljubljana. (2025). *Upravljanje s podatki*. Digitalna Ljubljana. https://digitalna.ljubljana.si/sl/cilji-in-ukrepi/upravljanje-podatkov/
95. Mestna občina Ljubljana. (n.d.-a). *Ozelenjujemo nadstrešnice avtobusnih postaj*. https://www.ljubljana.si/sl/moja-ljubljana/ljubljana-zate/pregled-vseh-projektov/ozelenjujemo-nadstresnice-avtobusnih-postaj/
96. Mestna občina Ljubljana. (n.d.-b). *Urbano čebelarstvo*. https://www.ljubljana.si/sl/moja-ljubljana/podezelje/cebela-v-ljubljani/urbano-cebelarstvo/
97. Ministrstvo za javno upravo. (n.d.). *OPSI - Odprti podatki Slovenije*. https://podatki.gov.si/o-portalu
98. Mohanty, S. P., Choppali, U., & Kougianos, E. (2016). Everything you wanted to know about smart cities: The Internet of things is the backbone. *IEEE consumer electronics magazine*, *5*(3), 60-70. https://doi.org/10.1109/MCE.2016.2556879
99. Moustaka, V., Vakali, A., & Anthopoulos, L. G. (2018). A systematic review for smart city data analytics. *ACM Computing Surveys (cSuR), 51*(5), 1-41. https://doi.org/10.1145/3239566
100. Nabatchi, T., Sancino, A., & Sicilia, M. (2017). Varieties of participation in public services: The who, when, and what of coproduction. *Public administration review, 77*(5), 766-776. https://doi.org/10.1111/puar.12765
101. Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities, 38*, 25-36. https://doi.org/10.1016/j.cities.2013.12.010
102. Niebel, T., Rasel, F., & Viete, S. (2019). BIG data–BIG gains? Understanding the link between big data analytics and innovation. *Economics of innovation and new technology, 28*(3), 296-316. https://doi.org/10.1080/10438599.2018.1493075
103. OECD. (2015). *Data-Driven Innovation: Big Data for Growth and Well-Being*. OECD Publishing. https://doi.org/10.1787/9789264229358-en
104. OECD. (2021). *Digital government review of Slovenia: Leading the digital transformation of the public sector*. OECD Digital Government Studies. OECD Publishing. https://doi.org/10.1787/954b0e74-en

105. OECD. (2023). *2023 OECD Open, Useful and Re-usable data (OURdata) Index*. OECD Public Governance Policy Papers. https://doi.org/10.1787/a37f51c3-en
106. OECD. (2024). *Digital public infrastructure for digital governments*. OECD Public Governance Policy Papers No. 68. OECD Publishing. https://doi.org/10.1787/ff525dc8-en
107. OECD (2025). *Government at a Glance 2025*. OECD Publishing. https://doi.org/10.1787/0efd0bcd-en
108. OECD. (n.d.). Sustainable urban development. https://www.oecd.org/en/topics/sub-issues/sustainable-urban-development.html
109. Ojasalo, J., & Kauppinen, H. (2016). Collaborative innovation with external actors: An empirical study on open innovation platforms in smart cities. *Technology Innovation Management Review, 6*(12). http://dx.doi.org/10.22215/timreview/1041
110. Ojo, A., Curry, E., & Zeleti, F. A. (2015, January). A tale of open data innovations in five smart cities. In *2015 48th Hawaii international conference on system sciences* (pp. 2326-2335). IEEE. https://doi.org/10.1109/HICSS.2015.280
111. Open Data Handbook. (n.d.). *Machine-readable*. Open Knowledge Foundation. https://opendatahandbook.org/glossary/en/terms/machine-readable/
112. Open Knowledge Foundation. (n.d.-a). *We are open advocates*. Open Knowledge - for a fair, sustainable and open future. https://okfn.org/en/who-we-are/
113. Open Knowledge Foundation. (n.d.-b). *Open definition - defining Open in Open Data, Open Content and Open Knowledge*. Open Knowledge - for a fair, sustainable and open future. https://opendefinition.org/od/2.1/en/
114. Open Knowledge Foundation. (n.d.-c). *What is Open Data?* Open Data Handbook. https://opendatahandbook.org/guide/en/what-is-open-data/
115. Opendatasoft. (n.d.). *Data ethics.* https://www.opendatasoft.com/en/glossary/data-ethics/
116. O'Reilly, T. (2010). Government as a Platform. *Innovations: technology, governance, globalization, 6*(1), 13-40. https://doi.org/10.1162/INOV_a_00056
117. Ortiz-Fournier, L. V., Márquez, E., Flores, F. R., Rivera-Vázquez, J. C., & Colon, P. A. (2010). Integrating educational institutions to produce intellectual capital for sustainability in Caguas, Puerto Rico. *Knowledge Management Research & Practice, 8*(3), 203-215. https://doi.org/10.1057/kmrp.2010.11
118. Osborne, S. P., Radnor, Z., & Strokosch, K. (2016). Co-production and the co-creation of value in public services: a suitable case for treatment?. *Public management review, 18*(5), 639-653. https://doi.org/10.1080/14719037.2015.1111927
119. Osborne, S. P., Radnor, Z., Vidal, I., & Kinder, T. (2014). A sustainable business model for public service organizations?. *Public Management Review, 16*(2), 165-172. https://doi.org/10.1080/14719037.2013.872435
120. Parasher, Y., Kaur, G., & Tomar, P. (2019). Green Smart Environment for Smart Cities. In P. Tomar & G. Kaur (Eds.), *Green and Smart Technologies for Smart Cities* (pp. 75-89). CRC Press.

121. Paskaleva, K., & Cooper, I. (2018). Open innovation and the evaluation of internet-enabled public services in smart cities. *Technovation, 78*, 4-14. https://doi.org/10.1016/j.technovation.2018.07.003
122. Paskaleva, K., Cooper, I., Linde, P., Peterson, B., & Götz, C. (2015). Stakeholder engagement in the smart city: Making living labs work. In *Transforming city governments for successful smart cities* (pp. 115-145). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-03167-5_7
123. Pestoff, V. (2012). Co-production and third sector social services in Europe: Some concepts and evidence. In *International Journal of Voluntary and Nonprofit Organizations*, *23*(4), 1102–1118. http://dx.doi.org/10.1007/s11266-012-9308-7
124. Praharaj, S., Han, J. H., & Hawken, S. (2018). Urban innovation through policy integration: Critical perspectives from 100 smart cities mission in India. *City, culture and society*, *12*, 35-43. https://doi.org/10.1016/j.ccs.2017.06.004
125. Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act). *Official Journal of the European Union*, L 152, 1-44.
126. Rodríguez Bolívar, M. P. (2015). Smart cities: Big cities, complex governance?. In *Transforming city governments for successful smart cities* (pp. 1-7). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-03167-5
127. Rogers, E. M. (2003). Attributes of innovation and their rate of adoption. In *Diffusion of Innovations* (5th ed., pp. 11-17). Free Press.
128. Rubalcaba, L., Strokosch, K., Hansen, A. V., Røhnebæk, M., & Liefooghe, C. (2022). Insights on value co-creation, living labs and innovation in the public sector. *Administrative Sciences, 12*(1), 42. https://doi.org/10.3390/admsci12010042
129. Shu, Y., Deng, N., Bie, A., Wu, Y., & Bao, S. (2024). Unlocking the role of smart cities in technological innovation: evidence from China. *Applied Economics*, *56*(58), 8273-8287. https://doi.org/10.1080/00036846.2023.2290585
130. Sicilia, M., Guarini, E., Sancino, A., Andreani, M., & Ruffini, R. (2016). Public services management and co-production in multi-level governance settings. *International Review of Administrative Sciences*, *82*(1), 8-27. https://doi.org/10.1177/0020852314566008
131. Simonofski, A., Asensio, E. S., De Smedt, J., & Snoeck, M. (2017, July). Citizen participation in smart cities: Evaluation framework proposal. In *2017 IEEE 19th conference on business informatics (CBI)* (Vol. 1, pp. 227-236). IEEE. https://doi.org/10.1109/CBI.2017.21
132. Simonofski, A., Asensio, E. S., De Smedt, J., & Snoeck, M. (2019). Hearing the voice of citizens in smart city design: the citivoice framework. *Business & Information Systems Engineering*, *61*(6), 665-678. https://doi.org/10.1007/s12599-018-0547-z
133. Tura, N., & Ojanen, V. (2022). Sustainability-oriented innovations in smart cities: A systematic review and emerging themes. *Cities*, *126*, 103716. https://doi.org/10.1016/j.cities.2022.103716

134. Umbrich, J., Neumaier, S., & Polleres, A. (2015, August). Quality assessment and evolution of open data portals. In *2015 3rd international conference on future internet of things and cloud* (pp. 404-411). IEEE. https://doi.org/10.1109/FiCloud.2015.82
135. UNESCO. (n.d.). *Data Governance in the Digital Age*. https://www.unesco.org/en/data-governance-digital-age
136. United Nations. (2025). *The Sustainable Development Goals Report 2025*. United Nations Department of Economic and Social Affairs. https://unstats.un.org/sdgs/report/2025/
137. Van Bastelaer, B. (1998). Digital cities and transferability of results. In *European digital cities: 4th conference: changing patterns of urban life, 29-30 October 1998, Salzburg, Austria* (pp. 61-70).
138. van Ooijen, C., Ubaldi, B., & Welby, B. (2019). *A data-driven public sector: Enabling the strategic use of data for productive, inclusive and trustworthy governance*. OECD Working Papers on Public Governance No. 33. OECD Publishing. https://doi.org/10.1787/09ab162c-en
139. Vanolo, A. (2014). Smartmentality: The smart city as disciplinary strategy. *Urban studies*, *51*(5), 883-898. https://doi.org/10.1177/0042098013494427
140. Vargo, S. L., Maglio, P. P., & Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. *European management journal*, *26*(3), 145-152. https://doi.org/10.1016/j.emj.2008.04.003
141. Wang, T., Liang, Y., Jia, W., Arif, M., Liu, A., & Xie, M. (2019). Coupling resource management based on fog computing in smart city systems. *Journal of Network and Computer Applications*, *135*, 11-19. https://doi.org/10.1016/j.jnca.2019.02.021
142. Wisdom, J. P., Chor, K. H. B., Hoagwood, K. E., & Horwitz, S. M. (2014). Innovation adoption: a review of theories and constructs. *Administration and Policy in Mental Health and Mental Health Services Research*, *41*(4), 480-502. https://doi.org/10.1007/s10488-013-0486-4
143. World Bank. (n.d.). *Urban population (% of total population)*. World Bank Open Data. https://data.worldbank.org/indicator/SP.URB.TOTL
144. Yadav, P., Hasan, S., Ojo, A., & Curry, E. (2017). The role of open data in driving sustainable mobility in nine smart cities. In *Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal* (pp. 1248-1263). AIS Electronic Library.
145. Yeung, H. W. C., & Coe, N. M. (2015). Toward a Dynamic Theory of Global Production Networks. *Economic Geography*, *91*(1), 29–58. https://doi.org/10.1111/ecge.12063
146. Yigitcanlar, T., & Teriman, S. (2014). Rethinking sustainable urban development: towards an integrated planning and development process. *International journal of environmental science and technology*, *12*(1), 341-352. https://doi.org/10.1007/s13762-013-0491-x
147. Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., Da Costa, E., & Ioppolo, G. (2019). Can cities become smart without being sustainable? A systematic

review of the literature. *Sustainable cities and society*, *45*, 348-365. https://doi.org/10.1016/j.scs.2018.11.033

148. Young, A., & Verhulst, S. (2016). *The global impact of open data*. O'Reilly Media, Incorporated.

149. Yu, C. H., Wu, X., Zhang, D., Chen, S., & Zhao, J. (2021). Demand for green finance: Resolving financing constraints on green innovation in China. *Energy policy*, *153*, 112255. https://doi.org/10.1016/j.enpol.2021.112255

APPENDICES

Appendix 1: Transcript of the interview with the head of the Office for Digitalization (translated to English language)

Date and location of the interview: 21. 5. 2025, 13:00-14:15, via Zoom online platform

Interview type: semi-structured personal interview

A) INTRODUCTION OF THE PLATFORM

As part of your Digital Development Strategy for the city of Ljubljana from 2023 to 2027, you define five strategic goals, one of which refers to digital tools for city management. How did the idea for establishing the Urban Digital Platform (UDP) originate and what steps were necessary to begin its development?

We recognized that with the rapid development of technology, one of the fastest-evolving sectors, we needed to make changes. It all began with an organizational shift. Our department, which used to be part of a city administration secretariat and non-existent on the organizational chart, was elevated to the level of other municipal departments. This change gave us more visibility and standing within the administration. We also reorganized internally and established two divisions: one for classic Information Technology (maintenance and upgrades of existing systems) and another for digital development and innovation. This second segment didn't exist before. With the establishment of new organizational structure, we laid the foundation to start addressing digital transformation. The first major project we tackled was the strategy itself, which took about a year and a half to fully develop. A strategy is a long-term effort. Ours runs from 2023 to 2027, but we will likely revise it before the end of 2027. Technology is evolving rapidly and we are talking about AI everywhere, but in two years, something else will dominate. So, the strategy must be updated accordingly. Projects like the UDP take years. It's not something you build in six months. One of the pillars is Digital tools for city management, which is a very broad concept. On the one hand, it refers to internal improvements, supporting internal processes of the municipal administration with digital tools. On the other hand, it concerns external users like citizens, businesses, public institutions and so on.

To go back to your question, where the idea came from. It was inspired by global trends, especially in Europe. We saw integration platforms emerging and realized it was only a matter of time before we would need one. But to even begin, we had to get organized first. We also hired new staff because the existing team could not handle the workload. You need to create the right conditions before executing a project. Many have good ideas, but skilled people and finances are needed to implement them.

What are examples of internal digital upgrades and open data strategies envisioned under this strategic pillar?

Internally, we are upgrading or replacing existing Information Systems, many of which are more than 20 years old and technically outdated or not integrable, making them difficult to connect with modern solutions.

Externally, this relates to the UDP, which is meant to function as an integration platform. This also includes the concept of open data. Open data will be part of this platform and synchronized with OPSI. So, whenever we publish a dataset on our portal, it will automatically appear on OPSI as well, complete with metadata and required standards. Usually, we do not transfer data directly but rather provide links to data sources, unless the datasets are smaller. It depends on the data type. Even though we talk about open data, certain types like APIs (Application Programming Interfaces) may require user registration. APIs are small programs that allow other developers to access our datasets indirectly. For example, someone developing a mobility app might use an API from our portal to access data about BicikeLj stations or electric vehicle charging points in Ljubljana. We want to know who is accessing these APIs to maintain oversight. If somebody misuses an API, we can track that and revoke the access. Our goal is not to restrict access, but to ensure control and safety. Because misuse could affect public services. Citizens usually cannot tell whether a malfunctioning app is official or not, whether it is municipal, national or a private one, that is why we must take care of the safety and reliability of the published data.

Can you share specific examples of municipal services that will be digitized within UDP?

Our goal for the platform is to offer municipal services that are currently managed in a physical form. For example, issuing parking permits for the inhabitants of the city of Ljubljana. Usually, from the end of November and early January, about ten thousand inhabitants visit municipal offices to get their annual parking permit. With digitalization, this process will move online and will not be limited to the calendar year, so from January to December. Instead, it will be valid for twelve months from the day of purchase, just like a high-way vignette. This will reduce the waiting times and long queues. It may sound simple, but it is not. Unlike vignettes, issuing permits requires verifying a person's permanent or temporary residence, which involves accessing the national population register controlled by the Ministry of the Interior. For this, we need a legal basis. Everything we do must comply with legal frameworks like data access, Data Protection Impact Assessment (DPIA), cybersecurity testing and so on. All of that takes time.

Another good example would be renting city gardens. The city rents out over one thousand garden plots. While this may seem straightforward, the process involves signing legal rental contracts. To digitize this, we must implement secure digital signatures, again requiring legal background to do it and integration with multiple systems. The platform is citizen-oriented.

You will be able to subscribe to notifications. For example, if there is a water outage, road closure or bus line detour affecting your area, you will be notified. You will have a personal account on the platform and choose what kind of alerts you want to receive.

Will UDP platform also be connected to existing applications like Ljubljana's public transportation application Urbana or similar?

Yes, it will. This will happen through what is known as a deep link. The idea is not that we fully integrate an app like Urbana into our new platform. Rather, within our UDP platform, there will be, for example, an icon that opens the Urbana app directly. The important part is that you will not need to log in again. That is the point of those deep links. At least for now, this is how we are solving it, because there can be many external apps and trying to fully integrate all of them would become extremely complex. Deep links allow for a more user-friendly approach and that is our main guiding principle, making everything as simple as possible for the user. But, as you know, simplicity is a broad concept. Some processes, due to legal requirements, cannot be simplified further. But we can simplify the experience. For instance, as I mentioned before, we enable a lookup in the central population register through the app. Although technically it is the user who performs the lookup. When they click on the specific field where their residence data is available, like home address, it will be automatically filled out, so they do not have to type it manually. In computer science, we try to avoid manual entries because of the high chances of making errors. So, if we can use standard codes or registers, we do so. However, taking that step forward also requires changes on the national level.

B) DATA MANAGEMENT, LEGAL FRAMEWORKS & OPEN DATA STRATEGY

What other legal, technical or operational challenges do you face when working with open data for the development of these services?

One key legal issue is making sure that personal data is not included. That is the first and most important thing. Then, even though the data is open, there still must be some control in place, especially if the data can be re-used in apps or services that could have a negative impact or spread misinformation. That is why it is good to know who is using it, even while keeping it open. Another challenge is setting the entire system up. You need the right people, knowledge and technology. If the municipality does not have that, the project will not work. Even if a city has datasets it could open, someone still must prepare them, attach metadata, validate the accuracy and make sure they are in the correct format (e.g., CSV file). This is real work. That is why we have built a backend module into the platform where we can prepare and manage these datasets. That also includes making a plan which we call a data opening action plan, like what OPSI uses. This plan will clearly define how data will be published, who is responsible for it and how often it should be updated. You also need a register of open datasets, so you know who manages what, how often it is refreshed. These backend mechanisms are essential for managing the entire system.

Have you checked how other cities within the EU approach open data publication when designing your portal?

Yes, we explored how some European cities manage this. One example I like is Open Data Gent. I find it simple to use and it even offers built-in analytics within the portal. For certain datasets, analytics are already prepared, which is great. We drew inspiration from that, although our solution is slightly different because we added our own ideas. One important distinction is that Gent's portal is standalone, not part of their city platform. In contrast, our open data portal will be a built-in service within the UDP. That is a substantial difference. We also liked how the city of Rijeka managed the content organization on their portal. You must think about how to structure the concept of your portal, what types of content it includes, such as traffic, environmental, healthcare data, how the search function will work, by searching for keywords or tags. All that needs to be planned. Why? Because the goal is to help users find the data they need as quickly as possible. For me, these platforms are living systems. You always discover something that could be improved or when new things emerge, then you adapt.

C) STAKEHOLDER ENGAGEMENT, INCLUSION & SERVICE SUSTAINABILITY

Do you collaborate with any external stakeholders, like private companies or startups, in the development of the municipal services?

Yes. Even while we were drafting the strategy, we involved external stakeholders. For example, we hired an external company to help us write it. We also held workshops with the public and internal stakeholders. In total, there were many workshops organized, including with municipal and city councillors. We presented and explained the goals to each group individually, what we are working on and what we want to achieve. When the time came to vote and approve the strategy, not a single vote was cast against it.

One crucial thing with initiatives like this is that if inhabitants will not use the services, we have a big problem. I hope that does not happen. That is why we are now starting to evaluate certain features through focus groups. You know the saying *"Every eye has its own painter"*, meaning everyone has different tastes and perspectives. Through these tests, we can identify things we may have overlooked or missed. That is the purpose of the feedback cycle, to improve the system based on real user experience.

In addition to municipal and city councillors and inhabitants, which you have already mentioned, who are the other stakeholders involved in the development process of the services?

We have also involved municipal public companies, such as JP VOKA SNAGA, LPP, LPT, Energetika and others. This platform is being developed at the city level, not just within the city administration. It is important to understand that Ljubljana has over one hundred or one

hundred and seven public institutions, if I am not mistaken. This includes all public kindergartens, the home care institute, the youth centre Mladi Zmaji and many others. Each of them has needs related to the digitalization of their processes, particularly in how they interact with citizens. One example is kindergarten enrolment. We have already partially initiated this together with the national government. There is a public application form available now, but it is still just a form. What is missing is the backend system. That is another service that might eventually be part of the platform.

How do you address the specific needs of vulnerable or digitally inexperienced groups, when designing and implementing new digital services?

That is a great question and a very real issue. Whether it is a matter of regulation or ethics, there will always be a certain percentage of the population, which we might call vulnerable groups, for whom you must maintain the traditional way of doing things. And that creates higher costs. Even if you build a digital version of a service, there are people, often older citizens, but not necessarily, who are digitally illiterate and will not use it. We cannot say, *"This service is available only digitally"*. That is why the EU has adopted principles and values for the digital environment, and one of the key ones says: *"Digital first"* but not *"Digital only"*. That distinction is especially important. That is also why I always say: digitalization is not cheap. Sure, an information system can eliminate manual data entry, but that does not necessarily mean it is cheaper. In fact, the cost of developing and maintaining it may be higher. But there are other benefits: greater accuracy, faster processing, improved analytics. Often, you even need new staff for implementation. And I think that management still struggles to fully grasp that. The cost side of digitalization is important and it does not get enough attention. Take open data as an example. You need mechanisms, policies, people, and technology for it to work properly.

Beyond focus groups with citizens, do you have other approaches in place to ensure that the open data you are publishing is truly needed or useful to the public?

I believe open data will be more useful for development institutions and companies that can create added value from it. Sometimes, there are great pilot projects developed by citizens, however, usually they fail if they are not maintained. That is normal. We already work with universities. They usually say: *"Can you provide data for this or that topic? We would like to experiment with it"*. So, we give it to them, though in such cases it is not yet published as open data because some of it still contains personal information and must be cleaned first. That is how we approach it: *"Can this dataset be made open?"*. That is the basic question. For example, data on public drinking fountains in Ljubljana. Drinking fountains have physical locations and no personal information, so it is not a problem to publish that. But you never know who might find such data useful. The duty of the city, the state or the public sector is to publish what can be published. Someone might surprise us with a brilliant or useful idea. What matters most to us is that we know the data is accurate. Secondly, we must know the update frequency, whether the data updates daily, weekly, annually. Let us say it

is spatial planning data, which probably changes once a year. But if it is parking space availability via sensors or water levels, that data updates in real-time. You need to understand the nature of the dataset to process and present it properly.

How do you distinguish between historical and real-time data and how do you manage each within the open data framework?

A good example is bus arrival data. That is what I call "live" or real-time data. It requires immediate access to a live system showing the actual arrival time. That kind of data cannot be stored in a data lake or database for instant use, it is too slow. Real-time data should be directly accessible as open data in the moment. However, once it has been logged, for example, yesterday's bus arrival times at a certain stop, which becomes historical data and that can be made available as open data later. Someone might then use that historical data for proactive analytics to determine whether buses typically arrive late or on time. Nowadays, forecasting algorithms are very advanced. You can build an app that predicts bus arrivals with 99% reliability. But to do that, you must build it on historical data.

D) INNOVATION, EU PROJECTS & FUTURE DEVELOPMENT OF SMART CITY SERVICES

In the cities of Helsinki and Kuopio, which I am using as excellent practice examples in the thesis, I noticed that they open datasets and organize competitions like hackathons. The best solution is then selected and the winners are invited to co-develop services with the city. Do you have any similar plans or ideas for the city of Ljubljana?

Yes, we have already done that a few times. We are familiar with that model. We often collaborate with Technology Park Ljubljana, which is where we also connect with startups. The park provides a startup-friendly environment and we work with them, especially in the areas of Artificial Intelligence (AI) and large language models (LLMs). We also keep an eye on the EU calls for proposals and participate in pilot projects or broader development initiatives, depending on our role. Sometimes we contribute data; other times, we actively participate in the project itself. It is true that Europe has been investing quite a bit in this area lately, not always 100%, but the support still goes a long way. That is another important aspect of partnership and networking.

We have touched on EU projects, one of them being the EU Mission: 100 Climate-Neutral and Smart Cities. How do you envision the development of smart city services in Ljubljana over the next years and how is it connected to that mission?

The main goal of the mission is to achieve carbon neutrality, meaning zero carbon dioxide emissions, by replacing fossil fuels with alternative sources. From the perspective of digitalization, we can contribute. Right now, there is a project running in Ljubljana that monitors urban heat islands. Sensors are being installed at various locations and various heights, not just at ground level, but also 3 meters up and even 40 meters. The goal is to

determine where these heat islands form in the city. This data could be used in apps, for example, in the citizen alert system. Imagine an app that shows: *"It is currently 40°C at this location. If you are sensitive to heat or have cardiovascular issues, we recommend avoiding this area"*. Or it could suggest: *"It's 40°C in the city centre, but only 30°C in Tivoli Park, consider heading there instead"*.

While carbon neutrality relates to emissions, it is also tied to broader activities: transport, heating, waste separation and so on. And digitalization plays a key role by enabling sensor networks and Internet of Things (IoT) systems. The ability to make decisions based on data is essential. This applies to city management, institutions, companies and citizens. If people have access to data, like water usage, drought predictions or how long they have watered their garden, they can make smarter choices. Maybe they will install a rainwater collector, for example, based on this data. But you can only act if you have the data. And collecting good data requires investment. Sensors are not free. If you want accurate data, you need a lot of them. That is why we are currently building the UDP, a centralized platform where all this data can be collected and managed. Until now, we did not have a structure like this. Whether it is a data lake or something else, the important thing is that there is an integration platform.

What do you see as the biggest challenges in developing and sustaining such smart services?

The biggest challenges are funding and personnel. First, we need people to manage and coordinate these projects while they are running. But just as importantly, once the project ends, we still need people to keep it alive. A lot of EU-funded projects end successfully, but then fade away because there is no post-project support. That is a major issue. Infrastructure remains in place and requires maintenance, which costs money. For example, we already have some sensors installed on Ljubljana's waterways, especially after the severe floods in 2014. Ideally, we would expand this to cover all waterways, but at the very least, we want to keep the system alive. And yes, there are maintenance costs. But the benefits of having this kind of real-time data far outweigh the expense.

So, we can say that the development of smart city services will follow both technological trends and the evolving needs of residents?

Yes, exactly. That is the direction we are heading in.

Will the UDP be free to use for residents?

Yes, the platform will be available as both a web and mobile application, like the Urbana app. The app itself will be free, but naturally, some services will not be, like purchasing bus tickets at the Urbana machines or allotment rentals. Those have always come with a cost and

digitalization does not change that. For example, the annual parking permit has always had a fee. The price was not introduced because of the platform. It was already in place. We were even able to publish the app on the Apple App Store for free by applying as a government entity. Apple checked and confirmed our status, so we were not charged anything. Google Play Store is a bit different, but in principle, we do not want to charge users for the app itself. Our interest is in seeing widespread adoption. For example, if 80% of people who used to come in person to get a parking permit do it digitally through our platform, that would be a remarkable success. Another good example is kindergarten enrolment. Based on our latest analysis, a significant percentage of parents are already enrolling their children through "e-Uprava" portal. That tells us we are on the right track and that it makes sense to keep developing and improving these services.

Appendix 2: Transcript of the interview with the head of the open data solution implementation within UDP (translated to English language)

Date and location of the interview: 6.8.2025, 15:00-15:35, via Zoom online platform

Interview type: semi-structured personal interview

A) OPEN DATA ON URBAN DIGITAL PLATFORM

My first question is related to the Urban Digital Platform (UDP) and an open data solution which will be available within this platform. Why did you decide to open data through the UDP?

We decided to publish open data on UDP because access to the open data portal will be available to anyone. Then those who will log in with SI-PASS or with a digital certificate will have some additional things. This way, we will have a better overview of the activities that are happening on the open data portal.

Now we are in the final phase of testing, so I cannot say what the experiences are, but I can say how it was before on an old data portal we had and because I also have certain services published on GIS servers, people always asked me if something had gone down, why something wasn't working. Then I realised that I had to look exactly at what was working on the server. This means that it is also used by foreigners from other countries who use it in their projects. This was the case of one Dutch resident who was making Open Street Maps and another three or four Slovenians. They divided up the Ljubljana area, each had their own, and then they went to look at the orthophoto image, the DOF, to see what was there, and then they drew it in so that the Open Street Map would be correctly drawn with all the symbology, with everything that was marked on it. That is it, meaning that there are people who look at it and I also like to invite others to go and look at it. For example, the Faculty of Arts, Department of Geography, uses it nicely and so on. I also get messages if something is not working.

What are the differences between the datasets currently published on the OPSI portal and those that will be published on the UDP?

The difference between what we have and what OPSI has is that OPSI is at the national level and publishes both national and local data, while we will have only local data for the MOL. Other local municipalities also publish on OPSI. But if you look on OPSI at what municipalities publish, it is mostly lists. We will make our own portal, which is on the same technical basis as the OPSI portal. When we will publish the data on UDP, an automatic process will run overnight and the OPSI portal will publish it on their side. So, we will not do anything manually. We already have everything set up, we are just waiting for the time when we go into production, then it will start running fully in the background.

I read your Strategy for Digital Development in the period from 2023 to 2027 and saw that under the fourth strategic goal you will open data gradually and that the data will be available to citizens, on one hand, and to companies, organizations, and educational institutions, on the other. I assume that these open datasets differ between each other. What will be the difference in the content of the data or its format depending on the target group?

I mentioned in the beginning that there are two levels of access. One will be anonymous, meaning that anyone can access it. Some will not need to log in, others can register, enter their email address and log in. The second level of access is via digital certificates. And they will be able to retrieve more data than these regular users, meaning that they will also be able to access some APIs. So, for example, sensors that are processing data automatically and can send you data updates every hour, they will be able to access that. Those who log in anonymously will not have that available. Why? Because someone could make a robot, make a thousand requests to it, and it could lead to a crash of the system, for example.

Then there will be data that will be within the large MOL family that will circulate through our channels, so where the MOL is the founder. These are primary schools, kindergartens, health centres, Voka Snaga, Energetika, Ljubljana´s pharmacies and so on. Those organizations where the MOL is the founder will get all that data I have already mentioned, plus the fact that we can exchange certain data among ourselves. Such data will not go on the OPSI portal. Because this type of data will be enriched, but we will decide whether to release certain ones or not. So, what we will do in the first phase are orthophotos, that is GIS, the areas of district communities, where the locations of district communities are. For example, regarding the locations of district communities, of which we have 18 in Ljubljana, we can say with point X, Y on the map, which would be another file showing where it is on the map. We can also give a .txt file, we can give it as JSON format, as GIS format, we can give it as Excel, for example. I also added regular files back then, a few years ago, for the needs of one project. However, the majority of the data we will provide, 95 percent or more, will be intended for everyone.

B) ADDED VALUE OF OPEN DATA

Now, in which areas do you see the greatest added value of open data for inhabitants of the city of Ljubljana?

The most is in what is demographic, because then you can do spatial analyses, how many people are there. And, if you have an innovative idea, you can do a lot in the background, for example, a good application, or take something from it and make better data. Because the thing is that we put our basic data out, what you will do with it is your idea, your imagination, where it leads you and what you want to do. From my side, a lot of this will be GIS data, so vector or cadastral data. For example, if we look at the so-called true orthophoto from 2019 onwards, which represents data about the land, surfaces, how much forest grew

each year up to this year 2025, it is interesting. These are master's theses and doctoral dissertations at the national level on this topic. The example of one of such papers done by students and researchers was how the overgrowth of a certain hill happened over the years. Also, all these orthophotos are still available, so a link can be added into their applications. The same goes with data formats known as Shapefiles that can be added into their applications via a link, which means that if an update comes on our side, it is automatically updated in their application.

This is from the point of view of residents and researchers, those who produce an idea and would develop a certain application. What about companies' point of view? Are there companies in Ljubljana that are interested in innovations in new services, for example start-ups or private companies?

If we look back a bit, I do not know how much you have followed in previous years, but first there was talk about digitalisation. The word digitalisation, we will digitalise everything, but everyone was just saying that, but nobody knew exactly what it was. That means if I keep some record in Excel, I digitalise it, put it in a database and put it in an application that supports it, collaborates with it and publishes whatever needs to be done with it. That means you need effort to do it. And if we put such things out, for example lists of healthcare institutions, someone can make an interesting application based on health. How many steps you need to take to get somewhere, navigation to get there, that is, imagination and how well you know the tool will influence what you will do with this data. With start-ups it is the same, they must recognise what can be done with the data with the help of imagination, of course. They really must be constructive and full of imagination. In the past you could not get orthophotos. You went to the surveying and mapping authority, you had to write why you wanted them to get the data and so on. Now it is free. It is one link, free access, anyone can download it. These are the advantages, faster access to everything. The surveying and mapping authority in recent years has expanded its basic layers, put everything on its e-space portal. The Statistical Office has a lot of things on OPSI. When we talked, they said that they had worked on synchronisation processes for a long time. It will be the same for us, we publish today, tomorrow it will be on the OPSI portal, because automation will work in the background. Whether you will browse on the OPSI portal or on our UDP portal, that depends on you. The only thing that will not be on the OPSI portal are our data in the form of zip files, but there will be a link to our portal, so that is the difference.

When writing my master's thesis, I came across the statement that open data is a powerful resource not only for residents but also for companies and organizations, as it can affect many areas, such as mobility, energy, economy, environment and so on. Based on your experience, where does the added value of open data come from in the development of city services?

The added value is this: there are several diverse sources available, if you connect them together, you make one source, your own source. And this source you can upgrade for that

application or whatever you are doing, which is very important. When it comes to city services development, we usually use open data and data which is available within our wider MOL family. An example from my work: I get data of all residents from the CRP (Central Population Register) of the Ministry of the Interior. That is, all residents with permanent or temporary residence. And I will also put this on all our area entities, those are district communities, then the areas of PGDs (Volunteer Fire Brigades) that also have a record how many residents are behind them. But that means I took one layer of district communities and took the data from the CRP. And when I paired this together, you already get added value. For our operational needs, this is also done at the level of a household. This means how many people are in a certain house or building (cadastre of real estate buildings), how many children, how many men, how many women, how old they are. But this is done for the needs of our protection and rescue department. So, if there is a fire, if there is an earthquake, they know how many people to look for inside or how many people they must take care of for accommodation, water, food and so on. This data at the level of a household will not be published. This data will remain within our group. But even within our large group, not everyone will have access to this data, only those who really need it. Within the open data portal itself we will be able to set everything exactly, who can see it, who cannot.

I understand. Now, regarding the security of the data itself, how do you ensure that open datasets are of sufficient quality, that they are up to date and that they are technically accessible for re-use, because I have read during my research it is important that open data is re-usable?

Each department or service is the custodian, administrator or itself produces certain data and it is the content owner that must take care of it. In each department or in public companies such as JP VOKA SNAGA, Energetika, LPP, they will themselves be the editors who will publish it, and it is their responsibility that the data is correct and high-quality. It is true that in the end we conduct a verification process when we check if everything is working and only then publish it. But those departments and services must be the ones who take care of the content. We are the ones who technically take care of the whole solution in the end. We technically check if it is technically acceptable and displayed, but for the content itself they are responsible.

From the previous interview I learned that there will be a contact person or administrator who is responsible for a specific dataset. Does this mean that each department will oversee their own datasets?

There will be a department or section available, and the email and phone number of that department. We will not give a name, because we also saw that the OPSI portal, when I spoke to them, also changed this. At the beginning they gave names, but then, for example, those eight datasets were in my name. What if I am no longer here and if I go to another job or somewhere else? That is why we put the department that manages it.

C) CHALLENGES AND FUTURE POTENTIAL OF OPEN DATA

What are the main challenges you face or have faced in opening these open datasets and in the use of open data?

For example, ethical challenges are present because we know that we cannot publish data of a national type. That is why we said that we will have an internal portal for the large MOL group. Another thing is that the start will be difficult. Because everyone must be educated, it must be shown to them how to publish the data, because they will probably have five datasets somewhere in some department or service (a public company will have much more open data to be published) and they will be a bit lost while using the platform at the beginning, so we will have to help them all the time. The third thing is how often this data will be updated: daily, weekly, monthly, yearly, or as needed. That means if someone forgot to update the datasets, then the changes will not be visible. So, someone must be here to remind them of this. They will be responsible for the content update. This will require the most work and effort. How to train certain staff to do this for the coming years. Because there is no guarantee that they will do it in the coming years. This is for publishing data. For reading this data from the portal, I do not think there will be problems. It may happen that a user notices that the data is not updated and then they will say: *"Please, update this dataset"*. So, there will be a feedback option on the portal itself, where the users can suggest improvements.

I also read that the European Commission defined high-value datasets in 2023, which national public sector bodies had to make freely available for re-use within a 16-month period. Did such datasets have to be published at the municipal level?

Yes, it is mandatory. A municipality is local self-government, it is just one level lower than the national government. The thing is that the Ministry of Public Administration supports municipalities to publish data. Municipalities must take care of publishing their data. The Ministry of Public Administration is the one that monitors that everything is going well and always encourages the publication of as much data as possible. Because then a large amount of open data comes out and you can use it to develop a new product or a service, because you get the opportunity. Otherwise, there would be no opportunity if that data were not published. We published a lot of data because of certain EU projects, where connected municipalities could work together to make an application. If we look at the Ljubljana valley, we know that there are many other municipalities nearby. And now, if all these municipalities opened their data, we would get a comprehensive result. This is an example for someone who takes it and makes something interesting for the whole Ljubljana valley if they had all the data available.

Regarding the future of open data, where do you see the greatest untapped potential for open data in the MOL? And in which areas should it be used better?

Over the years the only open data were annual reports of the companies. Every department, every service must write its part of the report. So, if you go through the report, you find out a lot. If you look through the websites, you also find out what a certain department is responsible for, what it manages and so on. If you just do such an analysis and you can find out what is behind it. And what will happen here in the next few years is that departments will have to start doing this by themselves. They will have to make sure that the data they have is publicly available and accessible. There is a huge amount of data and there will be even more in the years ahead.

Appendix 3: Transcript of the interview with the head of the Digital Development and Innovation Section (translated to English language)

Date and location of the interview: 7.8.2025, 13:00-14:15, via Zoom online platform

Interview type: semi-structured personal interview

A) PUBLICATION OF OPEN DATA IN LJUBLJANA

How is open data currently managed and published within your city administration, and what considerations influence this process?

As far as data opening is concerned, let us first agree on the definition of open data. If we now assume that this is the EU definition, that open data is freely accessible, not subject to payment and possibly, of course, the license CC BY 4.0, which only states the authorship or source, that it is free to use and machine-readable or accessible in machine-readable ways. Then we were, in fact, at a very low level of organization. By law, we were not strictly obliged to publish everything on OPSI. But still, in certain cases, at certain events, be it project applications, we had to publish them. However, it is crucial that when we started talking about open data, it should be understood in a slightly broader context of data management. In other words, open data is, for me, or at least the way we currently operate, just one segment of overall data management. Because not all data can be open. Personal data cannot be made open. However, certain anonymized collections or data sources can be. But we did not have a systematically addressed system within the city administration because it is organized according to needs in certain areas. The Surveying and Mapping Authority of the Republic of Slovenia is crucial for spatial data. That is the primary source. Then we have, for example, sources, demographics. When it comes to statistics, the primary source in Slovenia is always the Statistical Office of the Republic of Slovenia. That is where the official sources are. We are one of the reporters, while they are responsible for official statistics. And this data is freely accessible and published on SURS or SiStat and where spatially possible, also on Stage II. So, these are also sources for us. And again, we do not publish this data as our open data because it is not ours. But we collaborate with it, we encounter it in the process. To have the right and the duty to publish it publicly as open data, must come from there. First, it must be our data, we must own it. In other words, it must be generated in the course of our work, in the management of the city and of course it must not contain any personal data characteristics that could in any way identify a person. There are a lot of restrictions on what we can publish as open data. That is one thing, but we are aware that open data has gained popularity at the EU level over the years, we also have so many data acts. So, we have been dealing with this opening up of data more on an ad hoc basis. When a student needed certain things for research work, a master's thesis and we were the source, then we gave the data, of course. Now we are establishing our own portal. It is important to note that the back-end system also requires systematic uploading, which means a complete description of metadata, records, stewardship, ensuring that this data is always

published there, up-to-date, accurate, that everything is classified as it should be and that a single system for entering and uploading this data is set up in the back end. On the other hand, there is an interface for citizens, the public, for example, where they will be able to access this data in formats that we can provide.

Now, we have tackled this UDP project and open data portal establishment as a wider MOL family, which includes the city administration and all 140 institutions and public companies, because the key data is there and they, as managers of this data, must then decide for themselves whether they want to publish it publicly or whether they want something to happen with this data, perhaps, if they want feedback. For example, I send large amounts of data to certain faculties, which they use for exercises and theses, and it is good that during their studies, students in Ljubljana and researchers learn about everything we have available in the city. Our colleagues recognize the advantages of open data. I believe that open data will be needed by specific groups, such as students, researchers, and start-ups, and we are counting on them to find their way around this portal and help us improve it over time. With initiatives, depending on what else they would like, what would be useful to them, so that we can give priority to certain areas that would be of interest to specific groups.

B) OPEN DATA IN PRACTICE AND INNOVATION EXAMPLES

Can you provide examples of how open data has been used to drive innovation or create value in the MOL?

One of the best examples is Ljubljana Public Transport (LPP). This story is older than smartphones. In fact, it dates to 2008. This was data about where the bus was because their system was relatively advanced, as it had to be for them to manage the buses, when to fuel them, when to change drivers. In other words, their work created a great need for good analytics. This then made it possible, as early as 2005, using Short Messaging Service (SMS) technology, to send a request and receive a real-time SMS telling you when the bus would arrive. So, back then, mobile telephony only allowed for this. You could also do this via the website. In 2005 it was completely open, but no one was developing apps at the time because they did not exist. Apps came in 2008 with the first smartphones. The Apple Store opened in 2008. At that time, the need for this data began to grow. In 2010, high school students and developers in training developed applications for predicting bus arrivals because it was the only such mass source with which they could train. And it was two o'clock when our displays went down, when the applications went down, because everyone was calling the database. Then, from 2010 to 2012, the system was renovated and rebuilt. The EU project and the Jožef Stefan Institute came to our aid and put things in order, so that now this system for accessing this information is different, secure and stable. However, we still notice that this data is sought after and in recent years many master's theses at the Faculty of Electrical Engineering and the Faculty of Computer Science and Informatics in Ljubljana have been written on the topics of developing an application for bus arrival prediction with a sub-topic.

Another interesting example is chatbot named Troljo, which is available via Facebook's Messenger or Instagram. You just simply type a bus station name in Ljubljana, you will get a list of bus arrivals. A small start-up community produced this idea and it works based on real data. They also maintain it. So, Troljo is another application that was created using open data from the MOL.

Besides transport and urban mobility data, are there other areas where you have noticed open data has been widely used?

Yes. We have this DEAS project, the purpose of which is to identify which open data can be used to develop new and effective services, acquire new data by installing sensors and publish such data on open data platforms. We set up sixteen water level measuring stations, for which we created APIs so anyone can subscribe onto notifications and monitor water levels that are located close to households, so that flood threats can be predicted and if possible, avoided in the MOL. This had been done primarily for emergency services like firefighting, but we made the data openly available. The challenge here is the time spent maintaining such open data infrastructure because sometimes those water level sensors break and currently, we have four of them that need to be fixed. Unfortunately, due to other obligations and tasks that we have on the daily basis, we simply cannot devote all our time on open data initiatives, as we have many other duties as municipal department. Our primary duty is serving the local community.

Do you have any examples of how open data is being used during hackathons or by start-ups, since I have read in many research papers that such open data utilization supports innovation and entrepreneurial growth?

Another example related to start-up innovation was when we had an ad hoc open data portal from 2018, and it was an event (start-up hackathon), and they asked us if we could give them some challenges. They were developing some applications, and of course, it is in this application development that the potential for growth of the data economy is most evident. If I develop an application, I will profit from it. This is where the greatest interest lay. At that time, we had a hackathon, and anonymized data on violations recorded by the traffic warden office, which has a very good support system, was uploaded, exported, names were removed, and this data was made available to these start-ups. Based on this data, they developed a useful application that showed the statistical probability that you would get a parking ticket on Tuesday morning at 8 a.m. on Adamič-Lundrovo embankment because that's when the traffic wardens are most often there. It was an interesting solution. People here come up with "out of the box" solutions, they can see something completely new, something entirely their own. And of course, things can then be labelled as innovative. Similarly, some start-ups produce an idea and ask us for data, or they take citizens' initiatives and create a solution with a chatbot based on Artificial Intelligence and then they show us: *"Look, we could have this"*. But it is not that simple, because we also have the national legislation and we have to follow certain rules when publishing such services or applications.

How do you use your own data to innovate services internally?

A very concrete example is our newly integrated notification system which will be available on UDP platform when it will be published. Until recently, each public company or service like JP VOKA SNAGA, Energetika, Prom Info had separate systems. Citizens had to subscribe to each one individually. Now we are combining them in one place, so a person can subscribe only to what matters for them in case changes or reroutes are present in their street, their daily bus line, or other specific types of alerts. The aim is not to overload people with too much information but to let them personalize what they receive. This is also innovation, not by publishing raw datasets, but by using our own data smarter and more efficiently.

Do you also expect to get feedback from citizens and develop new services based on their needs?

Yes. We are already digitizing certain processes, such as renting garden plots in Ljubljana or applying for parking permits. These used to require people to come in person and apply for them manually in the office. Now the whole procedure will be online when UDP platform will be established, including payments and electronic contracts. UDP platform is built from open-source modules, so we can keep expanding it with new services every year. As usage grows, we also expect to receive ideas from citizens and communities about what else they need. This is where innovation comes in. We believe in creativity within the community.

And regarding other services, like up-to-date notifications of road closures or bus reroutes, are those based on open data, too?

Some data are still only accessible within the closed systems of their owners. LPP's data are open, but with controlled access, meaning you need to submit a request in case you want to use their open data and commit to how you will use them. Other municipal datasets we use internally are not fully open and for now there is no interest in publishing them raw. With the establishment of UDP platform, we will have the environment or space where we will publish our own data. This connects to the European shift toward data spaces. Unlike traditional open data, the European data space for smart communities introduce governance, interoperability and even payment systems. Sensitive data can be shared securely without being made public. Something similar is already being done by SURS (Statistical Office) that has a safe room where researchers and other users can access microdata under strict conditions and make their own opinions and observations based on that data. Ljubljana is already involved in the European data space for smart communities. Our vision is to gradually develop our own open data portal in this direction, with modules for governance, secure access, identification and possibly paid data, if we talk about the data coming from the private sector for which such companies want to earn some profit.

C) FUTURE OUTLOOK OF OPEN DATA IN LJUBLJANA

What role do you see open data playing in driving innovation and development in your city, and what challenges or future directions do you foresee?

If we ask ourselves now how much we see this influencing broader development, or internal development, or innovation, then, as the head of this department, I believe in the positive role and influence of open data utilization. However, we must draw your attention to a conversation we had with the city of Heidelberg, which already had a good open data strategy years ago. As part of smart city concept, they created an "urban data platform" and published their open data there. However, they monitored this for a few years and were unable to identify the economic impact that is often discussed in theory. I believe we could use our open data portal to take things a step further with the European data space for smart communities. Such data spaces are a step further and they are also being established through the European Commission. The restrictions are present in the private sector, which also produces data, but because they are not the public sector, they do not want to make it available for re-use without clear authorship, without control or without payment. Now, several of these data spaces have already been established to determine governance, what kind of access there is, so there are more rules, from architecture to standards, so that they are interconnected and comparable. This means that I describe a bike path in Ljubljana using the same types, according to a single standard and that publication is mandatory for those who need it in open CSV, shapefile format, and even JSON. Even more relevant formats for us now are these City JSONs, and the standardization of this data is also underway, so that someone from Norway who is interested in this and wants to make some comparisons, analyse and group can easily switch to it. So, all of this is done through these data spaces. This is because private companies are also included, as they have a huge amount of data. For example, companies that do not want to publish their data just like that because of competition, but in a converted or transformed form, they can also specify a payment for this and smart contracts in the API. So, these data spaces are more than just open data. It can happen that open data is available for some time on the data portal until someone realizes that such type of data falls under the GDPR and should be closed. On the OPSI portal, this happened with newly registered vehicles by months. Years ago, we were still recording and processing them, and from this data, we could monitor how many electric vehicles there were in Ljubljana when we wanted to determine the trend, and what the needs were for an electric charging network. We took this data and looked at how electric vehicles were growing in Ljubljana and the surrounding area. Now this data is classified, the Ministry of Infrastructure is no longer allowed to publish it, so we have to obtain this data in the traditional way. I am an advocate of having as much data open as possible, as we are sometimes a little too rigid when it comes to what constitutes personal data. When opening data in local government, i.e. in municipal communities, there are legislative obstacles. If data is not ours and the owners are, for example, public companies, public institutions, and state institutions, we do not have the copyright to publish it. They must be the ones to say:

"Yes, we want to publish it". As a city administration, we mostly deal with individuals and companies, where personal data is what limits us. So now, in addition to the UDP we are setting up tools that allow certain collections to be closed for the public, but some of the colleagues will still have the access within this environment. We are now organizing a catalogue of open data collections and data sources, equipping them with formats, making them remotely accessible, not only for the needs of citizens, start-ups, researchers, but also internally. This is because the organization and accessibility of data is especially important. We have finally tackled this in a more systematic way.

In the following five years, what is your vision for open data in the city of Ljubljana?

In the next two to five years, we want to fully populate and structure our open data portal within UDP platform so that it has all the characteristics of a data space in terms of governance. That means datasets will be machine-readable, standardized, and interoperable at the European level. Citizens will be able to personalize access, researchers will be able to securely request sensitive datasets, and businesses will also have the possibility to contribute or use data under clear rules. The goal is not just to publish raw data but to build a living ecosystem, where data support innovation, research and creativity, while also respecting legal frameworks and protecting personal information. We might get some feedback from the architects one day, who will say they need more data related to their field or people who are interested in the structure of associations active in the field of social welfare. So, of course we will make such data available for them because there is such data available, for sure. We can provide it, but we have to be in contact with our users and listen to their feedback and needs in order to know in which direction we need to go.

Appendix 4: Script in programming language Python for OPSI portal analysis

The following Python script was used for the quantitative analysis of OPSI portal as part of my master's thesis. The purpose of using such a script was to collect, process and visualise data and information on all available datasets that were published as open data on OPSI portal at the time of writing this thesis, with a special focus on the datasets related to the Municipality of Ljubljana. This Python script directly connected to the OPSI CKAN API endpoint. Pandas library was used for processing the retrieved data and matplotlib for visualisation.

Importing needed libraries

```
import os, re, json, time, math, calendar
from pathlib import Path
from collections import Counter

import numpy as np
import pandas as pd
import requests
import certifi
import matplotlib.pyplot as plt
from matplotlib.ticker import MultipleLocator
from requests.adapters import HTTPAdapter
from urllib3.util.retry import Retry
```

Defining API base URL and open data filter

```
BASE = "https://podatki.gov.si/api/3/action"
FQ   = "isopen:true +state:active +type:dataset"
```

Creating output folder and checkpoint files for downloads

```
OUT_DIR = Path("opsi_outputs"); OUT_DIR.mkdir(parents=True, exist_ok=True)
CHECKPOINT = OUT_DIR / "opsi_raw_pages.ndjson"
RAW_EXPORT = OUT_DIR / "opsi_raw_all.json"
```

Configuration of paging and network retry behaviour

```
PAGE_SIZE     = 500
MAX_RETRIES   = 5
TIMEOUT_SECS  = 300
SLEEP_BETWEEN = 0.5
```

Configuration of plotting style

```
plt.style.use("ggplot")
plt.rcParams.update({"font.size":12, "axes.titlesize":14,
                     "axes.labelsize":12, "figure.dpi":300})
```

Saving a matplotlib figure as PNG

```
def save(fig, name):
    fig.tight_layout()
    fig.savefig(OUT_DIR / f"{name}.png", bbox_inches="tight")
    plt.close(fig)
```

Creating resilient HTTP session with retries

```
S = requests.Session()
S.headers.update({"User-Agent":"thesis-ckan-export/2.0"})
S.mount("https://", HTTPAdapter(max_retries=Retry(
    total=MAX_RETRIES, backoff_factor=1.5,
    status_forcelist=[429,500,502,503,504]
)))
```

Calling CKAN API and returning 'result'

```
def ckan_get(path, params):
    r = S.get(f"{BASE}/{path}", params=params,
              timeout=TIMEOUT_SECS, verify=certifi.where())
    r.raise_for_status()
    j = r.json()
    if not j.get("success", False):
        raise RuntimeError(f"CKAN success=false for {path} {params}")
    return j["result"]
```

The figure is shown in the subchapter 5.2.1

```
Categorisation of published open datasets based on machine readability and non-machine readability
```

```
import os
import matplotlib.pyplot as plt
import pandas as pd

OUT_DIR = "opsi_outputs"
os.makedirs(OUT_DIR, exist_ok=True)

MACHINE = {"CSV", "XLS", "XLSX", "JSON", "XML", "RDF", "SHP", "GEOJSON", "TSV", "ODS", "PARQUET", "PCAXIS"}

# Expanding non-machine-readable categories for robustness
NONMR_PDF  = {"PDF"}
NONMR_DOC  = {"DOC", "DOCX"}
NONMR_PPT  = {"PPT", "PPTX"}
NONMR_IMG  = {"JPEG", "JPG", "PNG", "GIF", "JIF", "TIFF", "BMP", "SVG"}
NONMR_ARCH = {"ZIP", "RAR", "7Z"}
NONMR_TEXT = {"TXT", "TEXT"}
NONMR_ALL  = NONMR_PDF | NONMR_DOC | NONMR_PPT | NONMR_IMG | NONMR_ARCH | NONMR_TEXT | {"HTML"}


def norm_fmt(x):
    if not x:
        return ""
    return str(x).strip().upper()

def formats_set(res_list):
    if not isinstance(res_list, list):
        return set()
    return {norm_fmt(r.get("format")) for r in res_list if norm_fmt(r.get("format"))}

if "format_set" not in df.columns:
    df["format_set"] = df["resources"].apply(formats_set)
```

```python
# Categorisation with explicit rules
def categorize(formats: set[str]) -> str:
    if not formats:
        return "Unspecified"

    has_html = "HTML" in formats
    mr_set   = formats & MACHINE
    nonmr_set = (formats - mr_set)

    if formats == {"HTML"}:
        return "HTML-only"
    if has_html and len(mr_set) > 0:
        return "HTML+MR"
    if (not has_html) and len(mr_set) > 0 and len(nonmr_set - mr_set) == 0:
        return "Machine-only"
    if formats == NONMR_PDF:
        return "PDF-only"
    if formats.issubset(NONMR_DOC) and len(formats) == 1:
        return "DOC-only"
    if formats == {"JIF"}:
        return "JIF-only"
    if formats.issubset(NONMR_IMG) and len(formats) == 1 and ("JIF" not in formats):
        return "JPEG-only" if "JPEG" in formats or "JPG" in formats else "Image-only"
    if formats.issubset(NONMR_PPT) and len(formats) == 1:
        return "PPT-only"
    if has_html and len(mr_set) == 0 and len(formats - {"HTML"}) > 0:
        return "HTML+NonMR"
    if formats.issubset(NONMR_IMG):
        return "Image-only"
    if formats.issubset(NONMR_ARCH):
        return "Archive-only"
    if formats.issubset(NONMR_TEXT):
        return "Text-only"
    if len(mr_set) == 0 and (not has_html) and len(formats & NONMR_ALL) > 0:
        return "NonMR-mixed"

    return "Other"

df["category_refined"] = df["format_set"].apply(categorize)
```

```
# Counting and sorting by dataset number

exclude_categories = {"Unspecified", "DOC-only", "NonMR-mixed"}

cat_counts = (
    df.loc[~df["category_refined"].isin(exclude_categories), "category_refined"]
      .value_counts()
      .rename_axis("category")
      .reset_index(name="datasets")
      .sort_values("datasets", ascending=False)
      .reset_index(drop=True)
)

csv_path = os.path.join(OUT_DIR, "refined_category_counts_sorted.csv")
cat_counts.to_csv(csv_path, index=False, encoding="utf-8-sig")

# Colors per category

COLORS = {
    "HTML-only":      "#1f77b4",
    "HTML+MR":        "#ff7f0e",
    "Machine-only":   "#2ca02c",
    "PDF-only":       "#d62728",
    "DOC-only":       "#9467bd",
    "JIF-only":       "#8c564b",
    "JPEG-only":      "#e377c2",
    "PPT-only":       "#7f7f7f",
    "HTML+NonMR":     "#bcbd22",
    "Image-only":     "#17becf",
    "Archive-only":   "#c49c94",
    "Text-only":      "#9edae5",
    "NonMR-mixed":    "#aec7e8",
    "Unspecified":    "#c7c7c7",
    "Other":          "#393b79",

fig, ax = plt.subplots(figsize=(14, 7))

ax.set_facecolor("white")
fig.patch.set_facecolor("white")

fallback = plt.cm.tab20
color_list = [COLORS.get(cat, fallback(i % 20)) for i, cat in enumerate(cat_counts["category"])]

bars = ax.bar(range(len(cat_counts)), cat_counts["datasets"], color=color_list)
```

```
ax.set_xlabel("Category", fontsize=13)
ax.set_ylabel("Number of datasets", fontsize=13)

ax.set_xticks(range(len(cat_counts)))
ax.set_xticklabels(cat_counts["category"], rotation=45, ha="right", fontsize=12)
ax.tick_params(axis="y", labelsize=12)

ax.spines["top"].set_visible(False)
ax.spines["right"].set_visible(False)

for i, v in enumerate(cat_counts["datasets"]):
    ax.text(i, v, f"{int(v)}", ha="center", va="bottom", fontsize=12)

plt.tight_layout()

png_path = os.path.join(OUT_DIR, "refined_format_summary_sorted_colored.png")
plt.savefig(png_path, dpi=300, bbox_inches="tight")
plt.close()

print("Saved:", csv_path)
print("Saved:", png_path)
```

The figure is shown in the subchapter 5.2.2

Building monthly data update frequency line chart for 2023–2025 (2025 Jan–Aug only)

```
YEARS  = [2023, 2024, 2025]
MONTHS = list(range(1, 13))
monthly = pd.DataFrame(index=MONTHS, columns=YEARS, data=0)

for yr in YEARS:
    sub = df[df["modified_local"].dt.year == yr]
    if not sub.empty:
        vc = sub["modified_local"].dt.month.value_counts()
        monthly[yr].update(vc)

monthly.loc[9:12, 2025] = np.nan

monthly_out = monthly.copy()
monthly_out.index = [calendar.month_abbr[m] for m in monthly_out.index]
monthly_out.to_csv(OUT_DIR / "monthly_updates_2023_2025.csv", encoding="utf-8-sig")

#Combining into one line chart
fig, ax = plt.subplots(figsize=(12, 6))
x = np.arange(1, 13)
labels = [calendar.month_abbr[m] for m in x]
palette = {2023:"#1f77b4", 2024:"#ff7f0e", 2025:"#2ca02c"}

for yr in YEARS:
    ax.plot(x, monthly[yr].values, marker="o", linewidth=2.0, color=palette[yr], label=str(yr))

ax.set_xticks(x)
ax.set_xticklabels(labels)
ax.set_ylabel("Datasets updated")
ax.grid(True, axis="y", alpha=0.3)
ax.legend(title="Year", ncol=3, frameon=False, loc="upper left")

ymax = int(np.nanmax(monthly.values)) if np.nanmax(monthly.values) > 0 else 10
ax.set_ylim(0, int(ymax * 1.15))

plt.tight_layout()
plt.savefig(OUT_DIR / "monthly_updates_3years_one_chart.png", dpi=300, bbox_inches="tight")
plt.close(fig)

print("Saved:",
      OUT_DIR / "monthly_updates_2023_2025.csv",
      OUT_DIR / "monthly_updates_3years_one_chart.png")
```

The figure is shown in the subchapter 5.2.3

Institutions with the most open data publications on OPSI portal

```
from matplotlib.ticker import MultipleLocator

top_pub = df["org"].fillna("Unknown publisher").value_counts().head(15).sort_values()
fig, ax = plt.subplots(figsize=(14, 7))
ax.set_facecolor("white")
fig.patch.set_facecolor("white")
ax.barh(top_pub.index, top_pub.values)

for y, v in enumerate(top_pub.values):
    ax.text(v, y, f"{int(v)}", va="center", ha="left", fontsize=12, fontweight="bold")

ax.set_xlabel("Number of datasets")
ax.xaxis.set_major_locator(MultipleLocator(500))
ax.tick_params(axis="y", labelsize=12)

plt.tight_layout()
plt.savefig(os.path.join(OUT_DIR, "08_top_publishers.png"), dpi=300, bbox_inches="tight")
plt.close(fig)

top_pub.rename_axis("publisher").reset_index(name="datasets").to_csv(
    os.path.join(OUT_DIR, "08_top_publishers.csv"), index=False)
```

The figure is shown in the subchapter 5.2.4

Flagging open datasets related to Ljubljana

```
def contains_ljubljana(x: str) -> bool:
    return "ljubljana" in (x or "").lower()
def list_contains_ljubljana(lst) -> bool:
    if not isinstance(lst, list): return False
    return any("ljubljana" in str(v).lower() for v in lst)

df["is_ljubljana_related"] = (
    df["org"].apply(contains_ljubljana) |
    df["title"].apply(contains_ljubljana) |
    df["tags"].apply(list_contains_ljubljana) |
    df["groups"].apply(list_contains_ljubljana) |
    df["notes"].apply(contains_ljubljana)
)
```

Summarizing Ljubljana-related open datasets

```
lju_rel = df[df["is_ljubljana_related"]].copy()
fig, ax = plt.subplots(figsize=(4,3)); ax.axis("off")
ax.text(0.5, 0.62, "Ljubljana-related datasets", ha="center", va="center", fontsize=12)
ax.text(0.5, 0.36, f"{len(lju_rel)}", ha="center", va="center", fontsize=24, fontweight="bold")
save(fig, "10_ljubljana_count_card")

# Exporting Ljubljana-related table
cols = ["title","org","dataset_url","license_title","modified"]
lju_rel[cols].to_csv(OUT_DIR / "10_ljubljana_related_datasets.csv", index=False, encoding="utf-8-sig")

# Charting top publishers/organisations which published Ljubljana-related open datasets
pub_counts_lju = (lju_rel["org"].fillna("Unknown publisher")
                  .value_counts().rename_axis("publisher").reset_index(name="datasets"))
pub_counts_lju.to_csv(OUT_DIR / "10_ljubljana_publishers.csv", index=False, encoding="utf-8-sig")

top_pub_lju = pub_counts_lju.head(15).sort_values("datasets")
fig, ax = plt.subplots(figsize=(12,7))
ax.barh(top_pub_lju["publisher"], top_pub_lju["datasets"])
for y, v in enumerate(top_pub_lju["datasets"]):
    ax.text(v, y, f" {int(v)}", va="center", ha="left", fontsize=10)
ax.set_title("Ljubljana-related datasets — Top publishers")
ax.set_xlabel("Number of datasets")
ax.xaxis.set_major_locator(MultipleLocator(50))
save(fig, "10_ljubljana_top_publishers")
```