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Big data analytics for achieving smart city resilience

Key factors for adoption

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ABSTRACT (MAX. 200 WORDS):
The impressive growth of smart city initiatives can be widely witnessed worldwide. These cities are launched at the effort to improve quality of citizens' life and help city planners optimize and operationalize management of urban infrastructures. Smart cities are characterized by technologies and systems that are sources of high-volume and high-variety data sources which can be gathered, stored and analyzed by big data analytics for development and implementation of resilient smart city programs. These programs are solutions to challenges susceptible to smart cities as a result of global pressures such as climate change and social mobility. Nonetheless, how to fully adopt this technology and exploit the value of big data analytics for smart city resilience is still a key challenge facing most stakeholders. Since the adoption of new technologies in smart city implementing organizations turns out to be a complex venture and experience varies from city to city, this thesis aims to unveil the key factors for adoption of big data analytics for achieving smart city resilience. An understanding of the key factors for adoption is a key to a strategy to achieve smart cities resilience using big data analytics.

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Victor Zanabria

1 Introduction

This chapter starts with an overview of our field of investigation: the influence of big data analytics on smart cities resilience. It extends to a description of why this is a field of interest, from where the research question is stated and its underlying purpose and delimitation of this research is described.

1.1 Background

As the 21st century unfolds, urbanization combined with the overall growth of the world's population, tremendously increases the number of inhabitants living in urban areas (United Nations, Department of Economic and Social Affairs, 2014). With two thirds of the world's population residing in cities in the next decades (United Nations, Department of Economic and Social Affairs, 2014) the relevance of Information Systems (IS) on urban life and global urbanization topics is becoming more and more important (Abaker et al., 2016).

Making a city smart is arising as a plan of action to diminish the issues brought by an accelerated urbanization and the growth of the urban population (Abaker et al., 2016; Chourabi et al., 2012). In contrast to traditional cities, smart cities seek for different objectives, which are based on networked systems and distributed innovation processes (Pierce, Ricciardi, & Zardini, 2017). Moreover, a smart city approach entails taking advantage of cutting-edge technologies especially Information and Communication Technologies (ICT), to increase city resilience and life quality (Dameri, 2013). These technologies open a wide range of possibilities to provide new insights for decision making and innovation (Rathore, Ahmad, Paul, & Rho, 2016). As illustrated by Ericsson (2017), the volume of data generated will increase tremendously in the next years. By 2022, the world mobile data traffic per month will be at around 71 Exabyte of which 60% will be generated by devices related to IoT (Ericsson, 2017) which is an important component of any smart city. The generated data can be utilized to provide information to enhance smart cities applications (Al Nuaimi, Al Neyadi, Mohamed, & Al-Jaroodi, 2015) which opens the way to new technologies to support this purpose.

Nevertheless, smart cities are susceptible to the risks of meeting the needs of their growing urban populations. Global pressures that play out at a city scale such as climate change, economic fluctuations, social mobility and cybercrimes evolve new challenges for smart cities (Aldairi & Tawalbeh, 2017; Da Silva & Moench, 2014). A clear illustration of this can be seen in some smart cities in Sweden such as Malmö and Gothenburg, which have faced several challenges that threaten their ability to remain resilient (MSB, 2015). Some of these challenges including risks of flood, rise of sea level and rapid urbanization (Government of Malmo, 2011; MSB, 2015).

The scale of risks increases as the number of people living in smart cities increases (Da Silva & Moench, 2014). Risks become more unpredictable due to the complexity of presiding city

systems and the uncertainty associated with external hazards (Da Silva & Moench, 2014). In this aspect, a resilient smart city promotes a vision of the smart city in which efforts are addressed to increase the ability of the smart city to respond to heterogeneous pressure factors such as climate, environmental, energy and economics (Papa, Galderisi, Vigo Majello, & Saretta, 2015). This ultimately aim is to ensure a higher quality of life and sustainable urban development thus achieve smart city resilience (Papa et al., 2015).

One of the technologies that has been gaining popularity because of its advantages on managing and exploiting huge amounts of data is big data analytics (Chen, Mao, & Liu, 2014; McAfee & Brynjolfsson, 2012). The adoption of analytics and big data has grown over the last decade and organizations are working towards taking full advantage of it (Davenport, 2017). This growth can be explained by valuable insights for decision making and innovation provided by the application of Big Data and analytics (Phillips-Wren, Iyer, Kulkarni, & Ariyachandra, 2015).

The potential of big data analytics can be applied to examine the large amounts of data generated from smart cities and thus uncover hidden patterns, correlations and other insights which can support these smart cities to achieve resilience (Ghose, 2012). A clear use case can be seen in the case of the hurricane Sandy in 2012. The use of historical data, present weather conditions and appropriate computer models allowed meteorologists to predict the trajectory of the hurricane with a greater degree of precision which allowed to facilitate the safety of the citizens (Ghose, 2012). Another example can be seen in a study conducted by Giest (2017) which discuss the potentials of big data analytics to mitigate carbon emissions in smart cities including Malmö.

Nonetheless, opportunities are not the only factor to be considered for successful adoption of big data analytics. Potential challenges such as privacy, cybersecurity, data governance are also discussed in literature as barriers for adopting big data analytics for achieving smart city resilience (Aldairi & Tawalbeh, 2017; Hiller & Blanke, 2017). Furthermore, Davenport (2017) explains that despite the use of analytical technologies, it is also of key importance to aim attention towards developing nontechnical elements like analytical leadership, strategy and culture for successful adoption of big data analytics. It can be certainly argued then that adoption of big data analytics for achieving smart city resilience is characterized with factors such as opportunities, barriers and also affected by various determinants of adoption. Despite this general appeal, these key factors which pose as drivers, barriers and determinants for adoption of big data analytics for achieving smart city resilience have not widely discussed in literature (Giest, 2017). In particular, the key factors for the general strategic adoption of big data analytics in smart cities resilience need to be clarified in literature to give guidance in adoption to both academia and practitioners (Chauhan, Agarwal, & Kar, 2016; Kitchin, 2014).

Following the above discussion, the following section outlines the research objective and research questions.

1.2 Problem Area

It is evident above that the capabilities of big data analytics can be utilized in order to deal with risks and challenges that smart cities face to become resilient. Nevertheless, the key factors for big data analytics adoption in smart cities resilience is not widely covered in literature (Papa et al., 2015).

Most of available research has focused on the concepts and applications of big data and big data analytics in a smart city context with limited focus on smart city resilience (Abaker et al., 2016; Khan, Anjum, Soomro, & Tahir, 2015; Pan, Tian, Liu, Gu, & Hua, 2016). Furthermore, other literature have investigated the usage and adoption of big data analytics on smart cities from the technology perspective (Chauhan et al., 2016; Kitchin, 2014). Although these investigations reported many interesting results, the knowledge for key factors for adoption of the technology in smart city resilience by is limited, these factors are the key to any strategy to achieve smart cities resilience using big data analytic. For this reason, we argue that there is a gap in literature when it comes to understanding the key factors for adoption of big data analytics for achieving smart city resilience. Based on this argument our research questions that will guide this research are described in the section below.

1.3 Research Question

What are the key factors for big data analytics adoption for achieving smart city resilience?

In order to answer the question, we will investigate and analyze the following:

- How is the adoption process of big data analytics for achieving smart city resilience?
- What are the determinants to adoption of big data analytics for achieving smart city resilience?
- What are the key drivers and barriers to the adoption of big data analytics in the context of smart city resilience?

1.4 Research Purpose

To address the research question above, this research's main purpose is to investigate the technical and organizational factors for the adoption of big data analytics for achieving smart city resilience. This will be done through a focus on the following objectives:

- To identifying key drivers and barriers for adoption of big data analytics for achieving smart city resilience.
- To analyze the process of adoption of big data analytics for achieving smart city resilience
- To determine the determinants to adoption of big data analytics for achieving smart city resilience

1.5 Delimitation

In this context of the research question and problem area, it should be noted that the focus is to examine the key factors for the adoption of big data analytics in smart cities resilience. This does not cover the comprehensive technical insights and implementation of technologies in smart cities such as Internet of Things (IoT), smart energy, smart infrastructure, nor does it cover the application functionality or predictive algorithms of big data analytics. It should also

be noted that research results subject to interpretation are framed in the context of the selected city and can be replicated to others with similar challenges.

Furthermore, this study focuses on the adoption of big data analytics for smart city resilience at an organizational level. According to Davis et al. (1989) and Leonard-Barton & Deschamps, (1988) if the intention or usage by an individual is the subject of study, it is considered as adoption at individual level and if success of implementation by the organization is under study, it is considered as adoption at organizational level.

2 Theoretical foundations and domain of study

This chapter intends to establish the theoretical background of big data analytics in the context of smart city resilience. Firstly, pertinent literature in the big data analytics and smart city resilience domain will be reviewed, key barriers and drivers will be deduced from this review for drawing comparison at a later stage between empirical findings of the study and the academic literature. The chapter also looks at adoption theories that will be used to ground our discussion and findings. Based on literature review and the adoption theories a theoretical big data analytics adoption framework will be developed.

2.1 Big data analytics

This section introduces the different research angles of how big data analytics is defined by existing research. As big data and analytics, both buzzwords widely used separately and combined. Big data is defined by Gartner (2012) as voluminous (volume), high-velocity data (velocity) that comes in different formats (variety). But things have changed since then and challenges have arose in the world of big data. For this reason, the initial definition proposed by Gartner (2012) has been upgraded and two new attributes have been included: veracity and value. Veracity is a measure of truthfulness of data (Marr, 2015), the purpose is to avoid biases, noise, and abnormalities associated with the collected data. Value represents the meaning that can be generated from the elicited data where the main challenge is not collect it, but analyze it as well as making sense of it in a cost and time efficient way (Jagadish et al., 2014). Although other attributes have been discussed such as variability, visualization and volatility, we address the five characteristics which are as illustrated in the Figure 2.1.

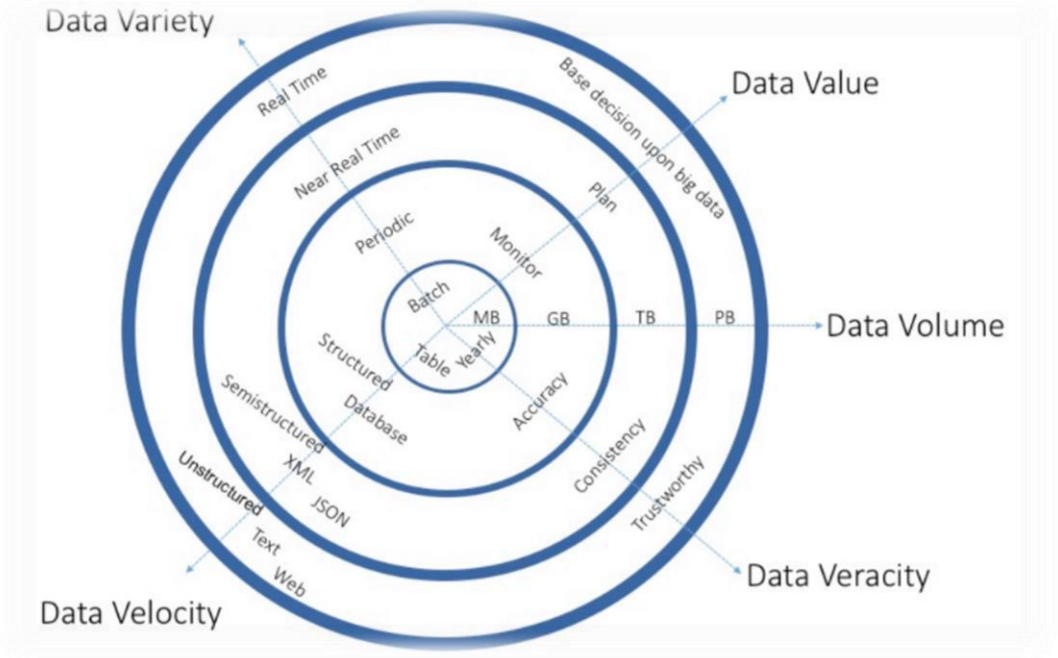

Figure 2-1: Big data definition (Henzelmann & Beer, 2015)

When it comes to analytics, a widely adopted definition was given by Davenport and Harris (2007) where analytics is defined as the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions. With the advent of big data, the way of doing analytics experienced some changes. According to Phillips-Wren et al. (2015) big data has added new dimensions to analytics by boosting the opportunities to generate insights, however new human and technical capabilities are required. When it comes to technical resources, the literature review discusses that the alternatives among hardware and software for big data and analytics have increased (Davenport, 2017). Likewise, the complexity has increased too, and it is required higher levels of expertise to work with.

The adoption of big data analytics is present in diverse areas such as economics, business, public administration, security, scientific research, just to name but a few (Philip Chen & Zhang, 2014). On the organizational context the potential of big data and analytics for providing new insights for decision making and innovation is huge (Phillips-Wren et al., 2015). The Increase of competitiveness and productivity in diverse industries has provided the base for big data analytics and its technologies to emerge (Phillips-Wren et al., 2015). This has called the attention of both academicians and practitioners, which can be evidenced in the increase of the number of papers focused on analytics and big data presented in leading IS conferences (PhillipsWren et al., 2015).

The big data analytics process is discussed through different frameworks of big data analytics in literature, for example the processes of data collection, storage, processing analysis and usage are widely discussed (Al Nuaimi et al., 2015; Hashem et al., 2016; Khan et al., 2015; Lv et al., 2017; Osman, Elragal, & Bergvall-Kåreborn, 2017; Phillips-Wren et al., 2015; Wang, Kung, & Byrd, 2018; Wu, Chen, Wu, & Lytras, 2018). In contrast, the process of security and management or governance are absent in many studies. Besides, although most processes are

mentioned, not all of them have received the same importance from the authors during the development of the literature review and discussion.
Despite the importance of big data analytics for decision making, there is still needed more literature to address the how the data should be analyzed and used (Davenport, 2017). There are diverse articles that delve into technical details, difficulties and challenges during the data collection, storage, processing and analysis. For instance, Osman, Elragal, & BergvallKåreborn (2017) presents different options during the analysis such as online analytics, real time analytics, batch data analytics whereas Hashem et al. (2016) focus on the emergent communication technologies used during the collection and storage processes. Lv et al. (2017) focus on storage and analytical technologies such as MapReduce, machine learning, streaming analytics, just to name a few. In short, storage, processing and analytical technologies have become widespread available and its benefits are explained. However, there is still work to do when it comes to explain the alignment of these frameworks with the organization's structure and strategy (Davenport, 2017).

Big data analytics plays a role in enabling organizations make use of data from various data sources, prepare the data, store to make faster and better decisions through sophisticated analytics. From literature review there is evidence of significant improvements from using big data analytics for better knowledge, prediction and decision management in smart city implementation (Khan et al., 2015; Ng, Xu, Yang, & Lu, 2017; Roski, Bo-Linn, & Andrews, 2014; Thaler & Tucker, 2013).

2.2 Smart city resilience

In order to understand the concept of smart city resilience, a literature review will look at both concepts: smart city and resilience and how the two are merged in literature. The aspect of making a city smart has emerging as a strategy to mitigate problems caused by the urban population growth and rapid urbanization (Chourabi et al., 2012). The overall smart city concept has gained increasing attention by academia, practitioners and decision-makers (Chourabi et al., 2012; Papa et al., 2015; Pierce & Andersson, 2017; Roscia, Longo, & Lazaroiu, 2013). The concept is used all over the world with different nomenclatures, context and meanings. Harrison et al. (2010) defines a smart city as an instrumented, interconnected, and intelligent city, where instrumentation enables the capture and integration of live real world data through the use of internet of things devices, the internet, and other alike data-acquisition systems, including social networks as networks of human sensors. Washburn et al. (2010) view a smart city as a collection of smart computing technologies applied to critical infrastructure components and services. A smart city is also defined as a city that monitors and integrates conditions of all of its critical infrastructures, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens (Hall, Bowerman, Braverman, Taylor, & Todosow, 2000; Hollands, 2008).

On the other hand resilience theory has multidisciplinary roots in the engineering, biological, and ecological disciplines, and is generally understood as a way to understand how systems react to extreme pressures whether they decline and die, or whether they adapt and thrive (Papa et al., 2015). Resilience is a relatively new term used in urban planning discussions, academic research and practice, this has been especially due to the increasing attention paid to extreme and catastrophic events and their consequences such as climate change, hurricanes, terrorist

attacks, earthquakes, fires, oil spills, cybercrime, epidemics as well as economic crises (Hudec, 2017; Papa et al., 2015). According to Papa et al. (2015) most commonly used definitions of resilient city have taken into account different disciplinary perspectives, considering social, economic and environmental factors, this is similar case for the definition of smart city. These definitions also consider their interrelationships as a key for an effective understanding of the complexity of urban systems and their behaviours in the face of heterogeneous pressures (Papa et al., 2015).

A resilient smart city promotes a vision of the smart city in which efforts are addressed to increase the ability of the city to respond to heterogeneous pressure factors such as climate, environmental, energy and economic, with the ultimate aim of ensuring a higher quality of life and sustainable urban development (Papa et al., 2015). On the other hand smart cities are rooted in the evolution and spread of ICT and in their outcomes in terms of globalization of economy and markets (Abaker et al., 2016; Chourabi et al., 2012). According to Dameri (2013) along its evolution path it has been increasingly used to indicate a city in which ICTs are addressed to improve the overall urban performances and, above all, the quality of life of its citizens. Despite the differences in the terms, there is a synergy in these two terms.

Due to the relevant synergies between the two concepts, some authors emphasize the increasing area of overlap among them (Papa et al., 2015). The resilience concept in smart cities' highlights that smart initiatives should allow cities to become more liveable and resilient and, hence, able to respond quicker to new challenges (Papa et al., 2015). In order to understand the linkage and interrelations between the two concepts, it is important to understand the common concepts between smart city and resilience. While all have different characteristics, the focus is on the common characteristics among the two concepts as shared by Papa et al. (2015) and summarized in Table 2.1 below. These common characteristics are namely transformability, learning capacity, persistence and adaptability. Learning capacity provides inputs for enhancing persistence, adaptability and transformation of the system, thus providing information that can be continuously processed used as an input to further increase the learning capacity (Papa et al., 2015). While adaptability is related to the capacity that systems will adapt to unforeseen situations, persistence referred to the ability of an urban system to maintain the characteristics and structures in the face of a threatening factor (Papa et al., 2015). Furthermore, according to Papa et al. (2015) transformability is defined as the capacity to create a new system when environmental, political, social or economic conditions make the existing one unsustainable.

Smart city resilience being a broader knowledge area can be implemented in various components of a smart city. This can be from provision of understanding of the complexity of cities and the drivers that contribute to their resilience to identifying critical areas of weakness and to identify actions and programs to improve the city's resilience (Da Silva & Moench, 2014). Furthermore addressing the issue of smart city resilient there are certain aspects that needs to be taken into account by stakeholders. While most studies have focused on the aspects of Urban planning (Da Silva & Moench, 2014), other studies have also included knowledge sharing between cities and stakeholders as important aspects (Ng et al., 2017). Others include leadership, strategy, health and wellbeing, infrastructure and ecosystem, economy and society (Da Silva & Moench, 2014).

Table 2-1: Characteristics of a smart and resilient city

Smart city resilience characteristics	Definition of characteristic
Learning capacity	Provides inputs for enhancing persistence, adaptability and transformation of the sys-tem in the face of climate change, thus providing information that, being continuously processed, can be used as an input
	to further increase the learning capacity
Transformability	The capacity to create a fundamentally new system when ecological, political, social or economic conditions make the existing one untenable.
Adaptability	The ability of an urban system to maintain the characteristics and structures in the face of a threatening factor.
Persistence	The capacity that systems will adapt to unforeseen situations

2.3 Big data analytics in the context of smart city resilience

To have insights on significant factors surrounding adoption of big data analytics in smart city resilience, this section explores how this technology is used in the context. As city services become more dependent on smart city data streams, the services also become more susceptible to disruptions (Da Silva & Moench, 2014). For this reason, smart city services require a level of resilience to disruption (Papa et al., 2015). ICTs which has increased urban smartness, plays a significant role in reducing vulnerability and improving smart cities' resilience. According to (Ospina & Heeks, 2010), ICT can help strengthen the physical preparedness of communities such as optimizing the location of physical defenses and strengthen institutions needed for the system to withstand the occurrence of climatic events.

Through deployed smart city technologies, high-volume and high-variety of data pertinent to the condition and performance of infrastructure systems along with the behaviors of citizens can be gathered, processed, integrated and analyzed through big data analytics platforms (Ng et al., 2017). This data can be generated from a variety of sources such as databases, sensors, social media, external apps, videos and images (Chauhan et al., 2016; Hashem et al., 2016). This data is required to be analyzed and refined using models to predict future outcomes with high reliability, and extraction of actionable insight to enable accurate decision making (Giest, 2017). These insights are considered to contribute to reduce foreseeable risks in different sectors of a smart city such as social mobility and climate change and thus enable effective planning in order to make smart cities resilient.

From the discussions above, data collection and integration of data in systems designed for a smart city is used in data analytics to facilitate smart cities resilience. This description is depicted in Figure 2.2 below. The Figure depicts a summary of big data analytics in context of smart city resilience. The big data analytics process consists of data collection, storage,

processing, analysis, usage, management and governance (as explained in section 2.1). The data analysis is used in various components of a resilient smart city described by Da Silva & Moench (2014) to achieve smart city resilience which is characterized by learning capacity, persistence, adaptability and transformability from study by Papa et al. (2015).

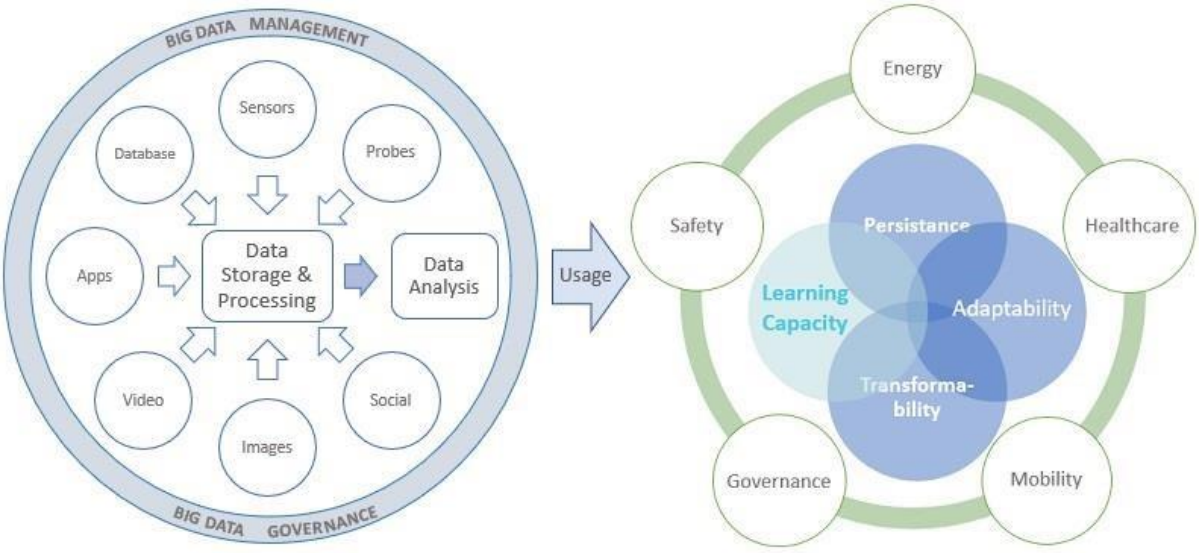

Figure 2-2: Simplified illustration of the interpretation of big data analytics in smart city resilience in this paper

2.4 Use cases of big data analytics in smart city resilience

This section gives examples of how big data analytics is used in achieving smart cities resilience as described in section 2.3 above. The underlying cases are based on components of smart resilient cities by Da Silva & Moench (2014).

2.4.1 Big data analytics in healthcare and safety

The capabilities of big data analytics to contribute in healthcare and safety for an external disruption like a natural disaster is evidenced in some cities. For instance, in 2012, hurricane Sandy made landfall on the eastern seaboard of the United States. According to Ghose (2012) the prediction of the trajectory of a hurricane is not always accurate however, the use of historical data, weather conditions and appropriate computer models, allowed meteorologists to predict the trajectory of the hurricane Sandy with a greater degree of precision. With the help of big data technologies, the US national hurricane center was able to predict hurricane Sandy's landfall 5 days in advance and within 30 miles in order to ensure the safety of the citizens (Ghose, 2012). Accordingly, the non-profit organization namely Direct Relief, used big data analytics plan and manage emergencies in near real time such as to identify vulnerable areas, stock up and distribute prescription medicines to the affected population in crisis time (Ghose, 2012).

2.4.2 Big data analytics in energy and governance

Diverse initiatives related to energy and governance for smart cities have been analyzed by cities around the world. An example of this can be seen on the commitment made by the Copenhagen City Council who in 2012 decided to adopt the Copenhagen 2025 climate plan to

become the world's first carbon-neutral capital by 2025. According to the City of Copenhagen, (2015), the application of big data and analytics is crucial so they can be able to make decisions in real-time and predict possible scenarios. Copenhagen plans to use the data collected not just as a tool to reduce energy but use it to contribute to policy making accordingly (IBM, 2013). Similar to Copenhagen, Malmö aims to combine a variety of data sources in order to develop targeted policies within the city (Malmö Stad, 2011) so that they can react accordingly against different situations. Likewise, Helsinki through an entity namely Helsinki Region Infoshare Project is bringing together datasets from its subsequent metropolitan region and puts the data open so that software developers, researchers and journalists can use the data for analysis (Caragliu, Bo, & Nijkamp, 2011). Analysis of these data sources has enabled availability of information such as real-time location of snow plows, map of traffic noise levels and others to name a few (Sulopuisto, 2014).

2.4.3 Big data analytics in mobility

Mobility and housing are components well related to big data analytics. A clear example can be found in the city of Los Angeles which uses automated traffic surveillance and control system (Lovett, 2013). The system is prepared to deal with different kind of issues like accidents or keeping public transportation running on time by adjusting the delay between semaphores' light changes when it is necessary. Another example is what Copenhagen is doing by implementing sensors to collect data from parking spots, traffic flow, garbage bins and water distribution to make decisions in real-time (City of Copenhagen, 2015). These city initiatives focus on integrating transportation and using ICT to have a better knowledge of the city as a whole and take more informed decisions.

2.5 Key drivers and barriers for adoption of big data analytics for achieving smart city resilience

While the general appeal and use cases of big data analytics in smart city resilience has been detailed explained in sections 2.3 and 2.4 above. Big data analytics adoption within smart cities for achieving smart city resilience is characterised by several promises of opportunities and benefits, alongside there are risks and challenges as well discussed in literature. The subsequent sub sections highlight these factors and discuss why they are considered as adoption factors in achieving smart city resilience. The underlying discussions will be based on adoption of big data analytics to achieving key characteristics of smart city resilience proposed by Papa et al. (2015) which are learning capacity, persistence, adaptability and transformability.

2.5.1 Key drivers for adoption

The adaptation of big data analytics in smart city resilience is looked in a way of enabling stakeholders generate possible strategies. This section reviews literature that looks at the potentials for big data analytics in achieving smart city resilience.

On aspect discussed is data sharing. According to Ng et al. (2017) big data analytics enables data sharing through different infrastructure systems in an interoperable and consistent manner,

for efficient smart city planning, and developing appropriate resilience and sustainable programs. Coupled with this, big data analytics supports collaboration particularly in emergency response management through distributed visualization environment for geographically dispersed users in disaster response (Natarajan & Ganz, 2009). Similarly, big data analytics enables data driven information exchange such as critical information exchange in disasters (Landwehr, Wei, Kowalchuck, & Carley, 2016; Qadir et al., 2016).

Big data analytics is discussed to enable smart cities process multiple diverse data sources distributed among connected entities and data sources thus create a knowledge base for the city (Osman et al., 2017; Phillips-Wren et al., 2015). Likewise Kitchin (2014) discusses the potentials of big data analytics to enable smart cities analyze and work with data from multiple sources such as data relating to environmental conditions may be collated and analyzed for insights and decisions. These data is collected from a sensor network distributed throughout the smart city, for example measuring air pollution, water levels or seismic activity. Clearly data from multiple sources of smart city results into high volumes of data. According to Landwehr et al. (2016) and Qadir et al. (2016) big data analytics enables smart cities to work with big volumes of data such as big data tools can be leveraged to process the large amounts of crisis-related data to provide an insight into the fast-changing situation and help drive an effective disaster response.

Big data analytics plays a vital role in improving decision making process through taking advantage of features such as different visualization methods and other big data assets, such as images, video, sound to increase reliability during decision making process (Phillips-Wren et al., 2015). Likewise Big data analytics enables situation awareness, supporting collaboration, decision making, and evaluating the analytical process itself using tools such as geovisual Analytics (Tomaszewski, Robinson, Weaver, & Stryker, 2007).

On the other hand big data analytics enables building of predictive models to investigate particular aspects of city life that change over time, and to build predictive models with respect to everyday city development and management and disaster situations such as flooding (Al Nuaimi et al., 2015; Kitchin, 2014). According to Akter & Wamba (2017), Kitchin (2014) and Koshimura (2016) big data is changing the humanitarian operations and crisis management dramatically through real time prediction giving smart cities ability to visualize, analyze and predict disasters. Analysis of public behavior in crisis management is also made possible through analytics (Chae et al., 2014). Real time analytics for disaster response and recovery (Chung & Park, 2016; Grinberger & Felsenstein, 2016; Koshimura, 2016)

Technologies like the Open Standard gives the opportunity to add flexibility for scaling and adding more applications in smart city to make it more resilient (Al Nuaimi et al., 2015; Schaffers et al., 2011). Such can be demonstrated in the design of resilient cities by development of technological innovation as an essential component in order to design a resilient city such as resilience against floods Renald et al. (2016).

2.5.2 Key barriers for adoption

Despite the promising opportunities, literature also discuss challenges and risks face the design, development and deployment of big data analytics in achieving smart city resilience as summarized in Table 2.2. Such challenges are barriers affecting smart cities resilience efforts

(Al Nuaimi et al., 2015; Fan & Bifet, 2012). This section reviews literature that looks at these challenges and risks for big data analytics in achieving smart city resilience.
One of the challenges discussed in literature is the inconsistencies of the legal and regulatory framework, this affects the stakeholders such as private companies compiling and analyzing city data (Höchtl, Parycek, & Schöllhammer, 2016; Letouzé & Johannes, 2014). On the other hand Phillips-Wren et al. (2015) discuss that there is no type of framework for the big data governance strategy able to fit with the configuration of a specific smart city. Organizations are still facing difficulties on building the technical and organizational skills and capabilities to tackle big data analytics for its effective implementation (Phillips-Wren et al., 2015).

The capacity to utilize big data within the urban planners for smart city specific goals is limited (Giest, 2017). Smart cities are also faced with high costs in aspects of having IT professionals, consultancy and training and the computational costs of data processing (Chauhan, Agarwal, & Kar, 2016; Khan et al., 2015). On the other hand, there are process challenges in finding the right model for analysis and the ability to iterate quickly (Li, Cao, & Yao, 2015). Data integration and data silos as a challenge and limited access to information collected by private companies and along with integration (Corradi, Curatola, Foschini, Ianniello, & De Rolt, 2015; Giest,
2017; Jara, Bocchi, & Genoud, 2013). Lack of Big Data analytics' platform between applications and services to provide data intelligence (Xiong, Zheng, & Li, 2014).

The increasing amount of data affect the performance of big data analytics systems and therefore the resilience of the city for example by 2022, the world mobile data traffic per month will be at around 71 EB which is nearly eight times higher than the numbers recorded in 2016, (Ericsson, 2017). A clear demonstration of this challenge is discussed by Grolinger et al. (2015) where as a huge amount of disaster related data is getting generated, traditional data storage and processing systems face challenges in fulfilling performance, scalability and availability needs of big data. Another aspect related to this is the challenge to mine patterns from city data (Bohli, Skarmeta, Moreno, Garda, & Langendbrfer, 2015) and delay in data fetching from remote storage devices or due to geographical constraints (Chauhan et al., 2016).

Security and privacy are vital success factors for analytics solutions in smart city (Bohli et al., 2015) including smart city resilience. The unregulated accumulation of data by numerous social media organizations is the biggest threat to security, as large sets of data tempt cyber attackers (Al Nuaimi et al., 2015; Chauhan et al., 2016; Kitchin, 2014). The possibility of illegal access or malicious attacks to data infrastructures can lead to catastrophic results affecting the city infrastructure, its government entities and its residents (Wolff, Kortuem, Cavero, & Keynes, 2015; Zhu & Zuo, 2015).

Other challenges discussed in literature includes technological lock-in from some of smart city systems and solutions (Kitchin, 2014), big data management as a challenge from data overcrowding and data redundancy (D'Aquin, Davies, & Motta, 2015) and inability to provide quality services to users by using fast processing engines to analyze big data sets on timely basis (Dobre & Xhafa, 2014; Koh et al., 2015).

Based on literature review above, Table 2.2 gives a summary of key barriers and drivers for adoption of big data analytics in achieving smart city resilience.

Table 2-2: Summary of key factors for adoption of big data analytics in achieving smart city resilience

Key drivers of big data analytics adoption in smart city resilience	Key barriers in of big data analytics adoption in smart city resilience
▪ Data sharing ▪ collaboration ▪ Knowledge base for smart city ▪ data driven information exchange ▪ Analysis of large volume of data ▪ Real time analysis and prediction ▪ Quality and Accuracy of Decision Making ▪ Increase of flexibility and scaling ▪ Increase opportunities for further developments of applications and services ▪ Design of resilient city plans ▪ Human behaviour analysis	▪ Challenges in mining patterns from city data ▪ Lack of legal provisions to enforce data policies ▪ Security Threats ▪ Data Processing Capacity ▪ Data Privacy ▪ Data Integration and Data silos ▪ Lack of Skills & Knowledge (Resources) ▪ High Costs ▪ Access to information collected by private companies ▪ Technological lock-in ▪ Lack of framework for the big data governance strategy ▪ Data management

2.6 Theoretical adoption framework

The understanding of adoption of technology in an organization can be approached from different theoretical perspectives. Based on the question to determine what are the key factors for big data analytics adoption in achieving smart city resilience, this study utilized the conceptual model for the process of IT adoption by Hameed, Counsell & Swift (2012). The subsequent descriptions in this section provides reasons for selection of this theoretical model and its detailed explanation with reference to big data analytics adoption for achieving smart city resilience.

According to Sharma and Mishra (2014), the rapid strides being made by technology innovations in every day has made technology adoption gain increasing prominence in recent times. Huge investments are made by organizations and governments for introducing new technologies that have potential of bringing new paradigm shift in style of users (Sharma & Mishra, 2014) as it can be evident in the design and development of smart cities and the adoption of big data analytics. Despite this argument, these investments may not yield results if the innovations are adopted by intended users, challenges and barriers are not identified and solved prior to investment and potentials for these innovations are not fully recognized and utilized (R. Sharma & Mishra, 2014)

Several studies including those of big data analytics adoption in smart cities (Abaker et al., 2016; Khan et al., 2015; Pan et al., 2016), have focused on aspects of technology as adoption challenge to technology adoption, however technology adoption is not related to the aspects of technology alone. Studies reveal that there are other factors that have evolved as a much more complex in adoption of technology such as leadership (Sharma & Rai, 2003), social influence

(R. Sharma & Mishra, 2014), culture and strategy (Davenport, 2017). Therefore, it is relevant that the theory to be adopted to cover several aspects of IT adoption within organizations.

The Diffusion of Innovation (DOI) theory, Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) have been widely used in IT innovation adoption studies (Hameed et al., 2012). Admittedly, theories alone would not fully explain all the aspects of organizational innovation adoption, hence, the research on organizational adoption needs to combine the adoption and implementation theories with frameworks from different contexts to examine innovation adoption (Hameed et al., 2012). The conceptual model for the process of IT innovation adoption by Hameed, Counsell and Swift (2012) fits this description and is thus adopted in this research. The model is relevant for this research because the model addresses IT adoption in organizations where the use of innovation would not entirely be under the control of users. According to Hameed, Counsell and Swift (2012) the model includes an interactive process approach and activities are examined at an organizational level perspective.

Hameed, Counsell and Swift (2012) combined theories of DOI, TRA, TAM and TPB and framework that consists of determinants of adoption called TOE (Technology/Innovation, Organization and Environment). These different attributes of each context impact different stages of innovation to varying extents. The TRA model provides constructs for users normative beliefs towards using the innovation while perceived attributes of TAM determine attitudes of the users in the user acceptance of IT and the DOI (Hameed et al., 2012). For the adoption processes at the organizational level, the model integrates DOI with a framework consisting of contexts of TOE. The combination of DOI with the framework allows us to evaluate perceived characteristics in the context of innovation, organization, and environment that affects initiation, adoption-decision and implementation stages of innovation adoption. The TRA model provides constructs for users normative beliefs towards using the innovation while perceived attributes of TAM determine attitudes of the users' in the user acceptance of IT.

The model consists of five categories of attributes that affect IT innovation adoption at organizational level. On the organizational level, the innovation characteristics looks at innovation factors that drive organizations to adopt IT such as compatibility, complexity and cost. This is in line with the research question we are trying to answer as it takes us into evaluation of what drives implementing stakeholders such as municipal and city councils to adopt big data analytics in smart city resilience. The Organizational characteristics examines the characteristics of an organization such as readiness, top management support, IS infrastructure, culture and resources within the boundaries of an organization. On the other, hand the environmental characteristics, includes external factors that influence organizational adoption of IT, these includes pressure from partners, government support, partners' readiness and external pressure. In the context of this research, we will consider environmental characteristics as external characteristics. From the individual level context, the conceptual model looks at the CEO characteristics which basically focus at individual characteristics that contribute to organizational adoption of IT. This characteristic, including factors such as CEO attitude towards change, and CEO IT knowledge. The final determinant is user acceptance attribute. This aspect is considered from organizational point of view and includes factors such as perceived usefulness, user experience and attitude towards use. However, based on the delimitation of our thesis. We will not include the individual level context of the conceptual model.

In conjunction to the above description, the adoption process consists of three phases, namely the initiation, adoption decision and the implementation. This study considers the initiation stage as the stage that consists of activities related to recognizing a need, acquiring knowledge or awareness, forming an attitude towards the innovation and proposing innovation for adoption (Hameed et al., 2012). The adoption-decision stage looks at the decision to accept the idea and evaluates the proposed ideas from various organizational perspective such as technical, financial, also this stage looks at the allocation of resources for its acquisition and implementation (Hameed et al., 2012). The implementation stage involves acquisition of innovation, preparing the organization for use of the innovation, performing a trial for confirmation of innovation (Hameed et al., 2012).

Based on the above discussions of IT adoption in organization, Figure 2.3 gives an extended model that is in line with our research question. The model be used in subsequent section to develop a compiled theoretical framework that will enable us to identify key factors for adoption of big data analytics in achieving smart city resilience.

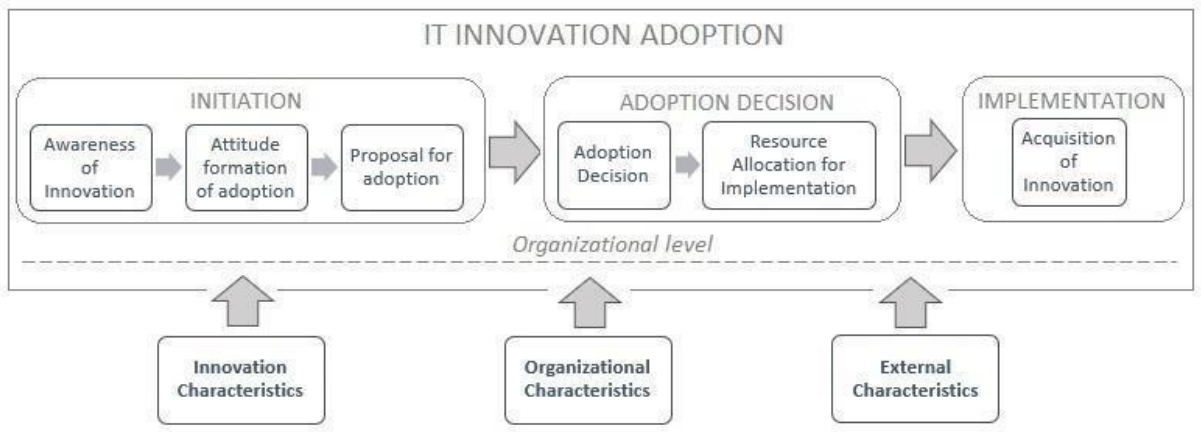

Figure 2-3: Conceptual model for the process of IT innovation adoption extended from Hameed, Counsell and Swift (2012)

2.7 Compiled theoretical framework

The core elements of this theoretical big data adoption framework as shown in Figure 3.4, are derived from the factors of big data analytics adoption in smart city resilience (see Table 2.2) and the conceptual model for the process of IT innovation adoption by Hameed, Counsell and Swift (2012).

In the theoretical framework, we identify IT innovation as passing through the stages described in the process of IT innovation adoption, namely the initiation, adoption decision and implementation of adoption (Hameed et al., 2012). This framework employs an interactive process approach and considers only the organizational level process of IT adoption.

We adopted the determinants of adoption for organizational level namely the innovation, organizational and the environmental characteristics. However, the environmental characteristic was renamed to external characteristics, to refer to external factors that influence

IT adoption in an organization. We excluded the individual level characteristics namely the CEO characteristics and the user acceptance attribute since they are not in line with the scope of this research.

The first category within our compiled theoretical research framework is labeled adoption process. The category covers activities related to recognizing the need, acquisition of the knowledge, evaluation of the technical, financial and strategic perspective. This category also includes the allocation of resources for acquisition and implementation. We chose to include the implementation phase to include acceptance of the innovation by various stakeholders and continued actual use of the innovation.

The second category within the compiled theoretical research framework covers the determinants of adoption. These determinants are adopted from the Hameed, Counsell and Swift (2012) model of IT innovation. The attributes of this category affect the initiation, adoption decision and implementation stages of IT adoption. We renamed the term environmental characteristics to external characteristics to make reference external factors that influence organizational adoption of IT. The CEO characteristics and user acceptance attributes were not included in our theoretical framework since they focus on the individual level factors that affect IT adoption and this is not part of the scope of our research.

The third category of key factors contains the different drivers and barriers towards the adoption of big data analytics. These are categories of the factors found in the literature review and summarized in Table 2.2.

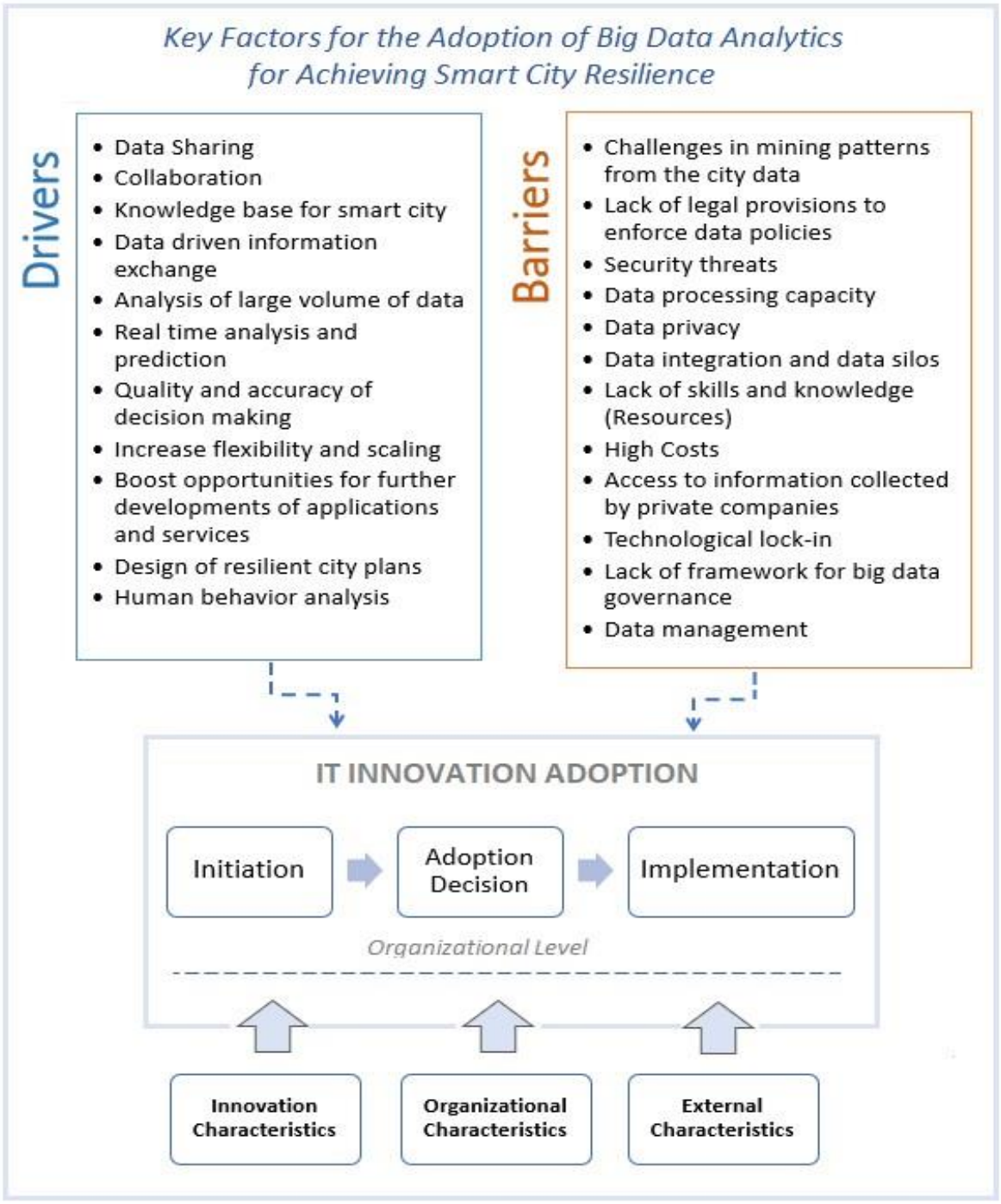

Figure 2-4: Compiled theoretical framework for the big data analytics adoption in achieving smart city resilience

3 Methodological approach

The purpose of this chapter is to describe the chosen data collection techniques that were applied to gather the findings of the study. The next segment outlines the data analysis and the coding process of the interviews. Finally, the quality and ethics of the study are discussed to ensure that the study adheres to the academic conduct.

3.1 Research strategy

Our research aims to identify the key factors toward the adoption of big data analytics for achieving smart city resilience. The literature review revealed that research concerning the organizational and technical factors regarding to big data analytics in the smart city resilience context was limited (Giest, 2017). Thus, a gap within current literature was identified, which allowed us to formulate the research questions through gap spotting (Alvesson & Sandberg, 2011; Recker, 2013). Our focus when selecting the appropriate approach for our study was to choose a methodology that allows us to collect and analyze data from a real-life context. In this scenario, Bhattacherjee (2012) explains that social reality unfolds based on the social contexts and individual experiences to produce subjective interpretations. Likewise, Recker (2013) supports this idea by claiming that the best way to study social reality is through subjectivism of interpretations within the socio-historical context. Considering this, it was logical for us to decide to follow a qualitative approach which will allow us to collect data in a setting where the participants of the study can interact while determining patterns or themes during the data analysis (Creswell, 2012).

During our qualitative research, we focused on the interpretation of data. This strategy allowed us to draw conclusions and patterns from data that was observed during our research process. Moreover, the use of interpretation is based on the nature of our research question that seeks to identify key factors of big data analytics in smart cities resilience. From here we developed interpretations of the researched context based collected and analyzed data. It is important to understand that the focus was on the interpretation of words more than of the numbers (Recker, 2013). Besides, the approach of the text analysis that was used is interpretive. This, according to Lacity and Janson (1994), will consequently lead to deal with subjective information. Finally, as researchers we played the role of an insider and the validity of our research was performed from a qualitative point of view.

3.2 Data collection

3.2.1 Data collection technique

In order to get the information required to answer our research question, we decided to perform a set of interviews within smart cities. In our research, we picked the cities of Malmö, Gothenburg, Lund and Helsingborg because of the city's initiatives to become a smart city and because of the challenges, they have been facing in terms of resilience. We decided to use

descriptive interviews since we wanted to get a rich description of the phenomenon and because we wanted to arrive at a comprehensive description of concepts in our research domain. The benefit of the interview questions is to enable us to focus on the complex issues through the open questions which give the possibility to the interviewer to gain a rich and insightful information (Recker, 2013). Using this technique, it is anticipated to gather a thick description of the opinions of the interviewees about the key factors for adoption of big data analytics for achieving smart cities resilience.

3.2.2 Interview Guide

Because of the nature of our study, we wanted to add a level of flexibility when it comes to gathering data during the interview to explore views and get answers based on the interviewees' experience. For this reason, we conducted a semi-structured interview where some questions were prepared beforehand, but there was room for improvisation, and openness (Myers & Newman, 2007).

Before the interviews, we consider the potential difficulties, pitfalls and problems of the qualitative interview in IS research such as lack of time, bias, lack of trust, the artificiality of the interview, just to name a few (Myers & Newman, 2007). We planned to have a clear understanding of the questions, their purpose and how each of them would contribute to our analysis and therefore to answer our research questions. Here we followed what was claimed by Kvale (1996) about the importance of the purpose before the method so that we can analyze what the interviewees say to enrich and deepen the meaning of the interviews.

To conduct and guide the interviews we developed an interview guide (as shown in Appendix A) that allow to us ensure that the interview questions address the proposed research questions. The guide also ensures that we extract the participants' knowledge from the respective domain. The guide consists of a set of questions that are harmonized with the research questions and is structured with three main parts. The first part is the introduction, it gives the interviewee an easy entry into the research question and eases the atmosphere. The second part, which is the main part, consists of questions that are directly related to the compiled research framework. This part gives an insight into the practical view of key factors towards big data analytics from practitioners' perspectives. The interview guide covers the topics in alignment with the theoretical framework in Figure 3.4 namely the process of adoption, determinants for adoption and the key drivers and barriers for adoption.

The final part of the interview guide which is the conclusive part, gives the interviewee an opportunity to add ideas, or any additional comment that they think are relevant to the research and perhaps was not well covered or elaborated. It also gives an interviewee an opportunity to give recommendation to another interviewee that may provide more information based on the information we are gathering.

Table 3.1 below shows the linkage between the theoretical framework and the interview questions. The factors of this research are used as constructs to link the compiled theoretical framework (see Figure 2.4) with the interview questions. It should be noted that some interview questions appear to be iterative in different constructs but the interpretation of the answers from interviewees varies based on the theme that is under interview.

Table 3-1: Interview questions from the interview guide aligned with the constructs of the research framework

Research framework constructs	Interview question
Adoption process	
Initiation	▪ What was the organizational incentive to adopt big data analytics solutions (what was the business case?) ▪ What smart city components (energy, mobility, housing, etc.) do you consider is being included in your organization? ▪ How would you describe your familiarity with big data analytics technology? ▪ How would you describe your familiarity with smart cities resilience? ▪ How would you perceive the concept of big data analytics for achieving a resilient smart city?
Decision process	▪ How important do you consider data management and governance in big data analytics? (e.g. what management tools are available)
Implementation	▪ How does the organization you work for, execute big data analytics against big data for enhancing smart city resilience? ▪ How important is collaboration and data sharing between smart city systems for interoperability and knowledge sharing? ▪ Could you describe your experiences in some of the projects you have been involved in? (smart city resilient projects)
Determinants of adoption	
Organizational Characteristics	▪ How do you consider the top management support for the initiatives of adopting big data analytics? ▪ How does the organization you work for, execute big data analytics against big data for enhancing smart city resilience?
External Characteristics	▪ To what extent do you think external influences (stakeholders) has contributed to big data analytics adoption? ▪ Who are the stakeholders involved in implementation of the project (s)? ▪ How can you state external stakeholder's readiness in terms of data access and collaboration? ▪ How do you manage data access and knowledge sharing between these stakeholders? ▪ What are the purposes stakeholders are considering, when implementing a big data analytics solution?
Innovative Characteristics	▪ Is there any impact of big data analytics on internal and external processes and relation-ships?

Perceived factors towards big data analytics adoption in smart city resilience	
Key drivers of big data analytics in smart city resilience	▪ How important is collaboration and data sharing between smart city systems for interoperability and knowledge sharing?
	▪ What was the organizational incentive to adopt big data analytics solutions (what was the business case?)
Key barriers of big data analytics in smart city resilience	▪ How do you perceive the complexity of handling big data analytics concerning tools, compliance or scalability? ▪ To what extent does technical uncertainties towards big data analytics adoption affect smart city resilience? (such as security of data, data integration, unstructured data, privacy of users) ▪ Where do you think are the main challenges of adoption of big data analytics for achieving smart city resilience? ▪ Can you give a concrete example from your experience?

3.2.3 Selection of respondents

In order to get the information required, this study relied on having access to knowledge from people with experience on the field. Thus, we needed to get in touch with people who were playing different roles at different levels within a smart city or a city that aims to be a smart city.

In order to reach our respondents, we used convenience sampling, expert sampling and snowball sampling to identify the people that were connected with our field of study. Through expert sampling technique, we were able to choose participants of the interviews based on the studied phenomenon and not on the random basis. The convenience sampling, later on, helped us to get the most proximal and accessible to experts from different smart cities in Sweden. With snowball sampling, we got referred to the right people from different municipalities or organizations to talk about topics related to the adoption of big data analytics in the context of smart city resilience. While doing this we decided to include people from different organizational levels and professions so that we can have a variety of perspectives, avoid bias and increase the richness of the study as suggested by Bhattacherjee (2012) and Myers and Newman (2007).

Additionally, interviewees that also included companies that are working with smart cities and city councils to implement smart city resilient projects. A list of interviewees and brief details of the interview and interviewee background is as shown in Table 3.2 below.

Table 3-2: Overview of Interviewees

Details of Interviewee			Details of the Interview	
Name of interviewee	**Position**	**Brief description of Interviewee**	**Date and Duration of Interview**	**Type of Interview**
Björn Lahti	Program Manager Smart Helsing-borg	Program manager of the program "Smart@Helsingborg" working with the development of the city of Helsingborg connecting people and organizations. Worked with big data analytics and systems capabilities such as geographic information systems.	30 April 2018/ 37 Minutes	Skype call
Jenny Åström	Project Manager for sustainable smart cities (Malmö)	Project manager of sustainable city projects for the development of the city of Malmö. Working with the preparation of the city against diverse global challenges.	04 May 2018/ 30 Minutes	Face-to-Face
Peter Kisch	Project Manager at Future by Lund (Lund)	Project Manager of the implementation of sustainable and smart innovations for the city of Lund. Working on the analysis and design for the digitization process of the city.	17 May 2018/ 46 Minutes	Face-to-Face
Jonas Norman	Head of Innovation Services (Innovation Management and Communication Group)	Work as one of the 12 managers assigned for business modelling for technologies within city systems for The European Commission. Working closely with the city of Gothenburg with a focus on implementation of new technologies for smart cities.	18 May 2018/44 Minutes	Skype call

3.3 Research quality

Research quality is very important for our research. In this section we are going to explain how we considered some important factors to ensure the quality of our research. At the beginning we will discuss factors such as validity, reliability explained by authors like Recker, (2013), Bhattacherjee (2012) and Seale (1999) as relevant topics for research quality. Later we will explain other factors that also influence the quality of the research such novelty, ethics and relevance of the study (Recker, 2013).

3.3.1 Reliability and validity

When it comes to reliability, it is challenging to achieve this due to the fact that it would not be likely to repeat the operations of the study in equal settings with the same results because this depends on the researcher's subjectivity (Recker, 2013). However, the interview guide, the recordings, and the interviews transcripts were provided and are attached to this research with the purpose of giving the reader the opportunity to assess the trustworthiness of the research.

Besides, the selection of the informants was performed thinking about having people with experience, who have been actively involved in projects related to the context of our study. In order to increase reliability, we decided to have access to primary information sources instead of secondary information sources that retell experiences of others which puts the credibility of the collected information at risk. Despite our desire to have an acceptable degree of reliability, we considered that innovations and variability might be affected if the interviewers were not allowed to follow interesting emerging topics during the interview by improvising questions (S Kvale & Brinkmann, 2009). For this reason, we decided to follow a semi-structured format for our interviews so that we can ensure an open process of communication but without losing the control of the boundaries of the discussion.

As well as reliability, we saw validity as a challenge in our research since validity can be an issue in qualitative research because of its requirements in certain factors such as correctness, truthfulness, and strength of statements (Bhattacherjee, 2012; Miles & Huberman, 1984). We are aware that since our research follows an interpretive approach the validity checks are going to be based on the acceptance of the scientific community (Lacity & Janson, 1994). Therefore, the quality of our research does not rely on quantification but on the interpretation of the data collected. Despite the challenges to ensure validity, we decided to cover two well-known categories of validity: internal and external validity. On the one hand, external validity refers to the generalizability of the findings in an alternate setting (Bhattacherjee, 2012; Seale, 1999). On the other hand, internal validity is concerned about providing enough evidence for the interpretations performed during the data analysis (Recker, 2013).

To set up internal validity for our interviews we decided to link our interview questions to the constructs presented on our theoretical research framework which can be seen in table 3. The idea here was to ensure that our interviews actually measure what it was supposed to be measured, accordingly to the technique of face validity. When it comes to external validity we also found challenges since qualitative inquiry is usually considered as a sample and therefore not generalizable from a statistic point of view (Lee & Baskerville, 2003; Seale, 1999). Nevertheless, Recker (2013) explains the application of transferability in the context of external validity. He highlights the relevance of providing valuable details of the research that allow readers to assess if it is possible to apply the findings to other fields of research. For this reason, we have provided diverse information so that the readers can be able to apply transferability based in the context of this research.

3.3.2 Ethics

Ethics is defined by Recker (2013) as the principles of right and wrong conduct in a community or profession and can be used by individuals acting as free moral agents to make choices to guide their behavior. Ethical challenges include plagiarism, securing consent to record interviewee, recognition of co-author contributions, honest reporting and appropriate use of language (Bhattacherjee, 2012; Recker, 2013).

In conducting this research, we maintained ethical practices both during conducting research and in writing the research. This was done by following guidelines such as LUSEM code of writing, AIS ethical codes for Information systems research and best practices to avoid plagiarism acts. For example, citation of ideas and thoughts that are not ours. In recognition of coauthor contributions, we acknowledgment notes are issued to all contributors to our work. In

use of language, the specificity, labeling and professional acknowledgments are also avoided in this research.

In our data collection technique, we ensured that there is actual consent from people to be interviewed, this was done by asking interviewees the consent to record the interview prior to started interviewing them. Besides, we asked them if their names could be shared in the interview or they wish to remain anonymous. This research is also based on honest and complete reporting of data from the selected cities. Moreover, there is fully disclosure our findings including negative results from our research findings, analysis of data was complete before evaluation of the theoretical framework and also data is not segmented to support our initial theoretical framework.

3.3.3 Novelty, relevance and interest

To evaluate the quality of research Recker (2013) states that, a good research has to be interesting to the investigator, novel and relevant. The topic is interesting to us because we have academic background of both topics: big data analytics and smart city and we are interested to answer the question of the influence of big data analytics in smart cities resilience. When it comes to novelty, as previously explained, there is a gap in the literature in the topic of our research. For this reason, we believe that it will spark discussions and open new opportunities to researchers and practitioners in the field of Information Systems. The relevance of this research falls on the idea of bringing together two relevant concepts namely big data analytics and smart city resilience. We argue that this will contribute to the IS body of knowledge, contribute to smart cities becoming resilient and again as stated above, spark discussions for future research questions.

3.4 Empirical analysis

In order for us to be able to perform an empirical analysis of the collected information, we decided to transcribe the audio recordings of each interview. When we talk about transcribing we are talking about the interpretive process where oral language is being translated in a written form (S Kvale & Brinkmann, 2009). While transcribing the interviews we decided to keep the word-by-word transcription since we believe that it is important to keep every detail in an interpretive research. For translating the audio files to a written form, we used a software called Otter, which is a tool that simplifies the transcribing process. The interviews were conducted in English, however, some interviewees preferred to say some words in Swedish in case that they were not able to explain them in English. We decided to translate these words into English in order to simplify the coding and analysis process. Finally, once the transcribing process was done, we proceeded to use the transcriptions as an input for our analysis process

The transcriptions were done immediately after the interviews were completed. The main idea was to start the analysis process before finishing the data collection. This overlapping was done to take advantage of the emerging themes obtained as a result of the analyzed data, in order to improve our data collection process (Bhattacherjee, 2012). For instance, it was easier to keep track of the interviews by transcribing them and analyzing them as soon as possible. This is because we did not have to put so much effort into understanding the transcripts since we could

more easily relate what was said by the interviewees. This allowed us not to get lost in large amounts of data at the end of the data collection process (Kvale & Brinkmann, 2009).

Considering that the purpose of this study is to understand the adoption process of big data analytics for achieving smart city resilience and identify the key factors for adoption in the process, we decided to perform our analysis by using the coding technique. This was done because of the capabilities of the coding technique to perform analysis over the texts obtained from the transcriptions. It was an advantage for us to design the interview questions in a way that allowed us to divide each transcript into different units of analysis which are tightly related with our research framework which is illustrated in Figure 3.4. We designed and organized constructs between the questionnaire and the components of the research framework previously as it can be seen in table 3. This allows us to identify concepts or key ideas over the coded data, as well as understand how they are related (Bhattacherjee, 2012). Besides, we considered the coding technique in our study because of its benefits when it comes to comprise the empirical data to relevant information (Recker, 2013).

There are different tools that allow performing the coding technique, but we decided to use nVivo for being a very well-known software for qualitative analysis and its benefits when it comes to organize, categorize and analyze data. Figure 5 shows an example of the coding process performed over one of the transcriptions. In this figure, the key concepts that were found in the transcriptions are highlighted with the purpose of categorizing them as well as assign them to their respective constructs. In order to achieve this, we built a link between the key concepts found in the transcriptions and the constructs proposed in our research framework, which can be seen in Figure 3.1.

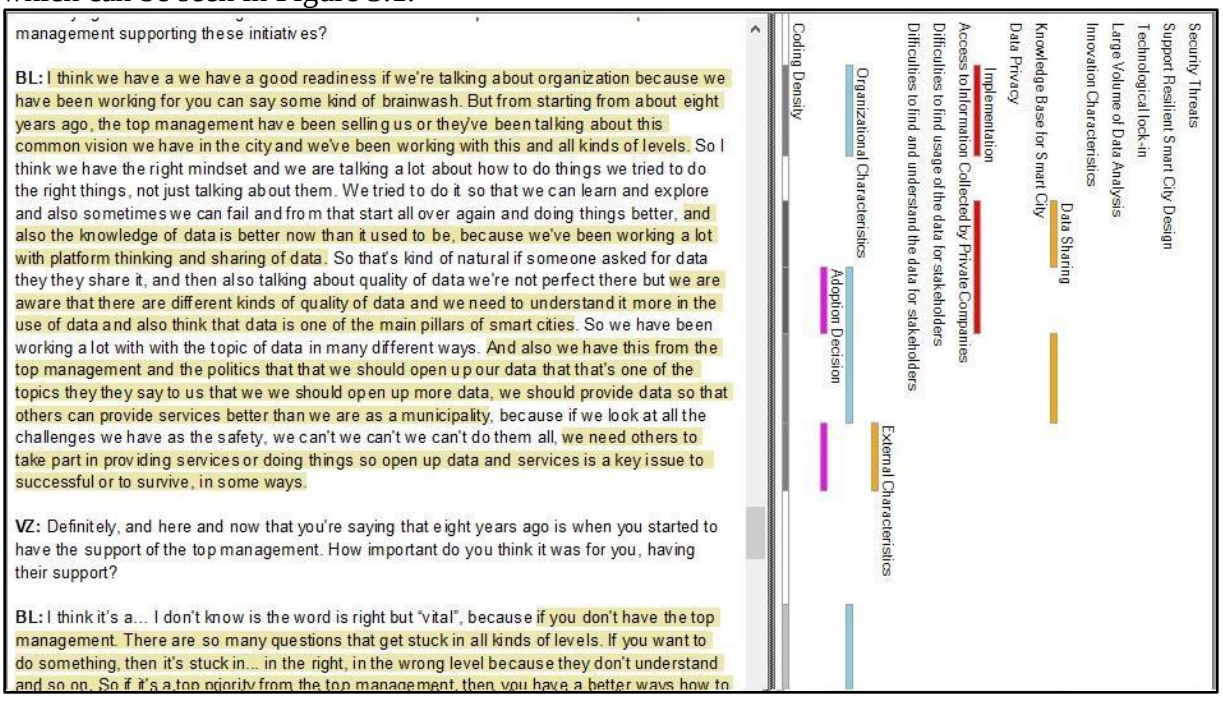

Figure 3-1: Example of the coding process using the nVivo software.

The coding was done by assigning each of the constructs from our theoretical framework to the key concepts, ideas or statements that were found in each transcript. Besides, while performing the coding process, we identify new constructs that we didn't consider in our theoretical

framework, which allowed us to have a better understanding of the phenomena. This a very interesting approach that will give us the opportunity to identify gaps in the literature and create a richer discussion later on. After finishing with the coding, we decided to identify and categorize the importance of every construct so that we can make a comparison between them. This was possible by looking at different tools that the nVivo software provided us such as an accumulated number of references of our constructs in every transcript and a variety of charts for comparing the number of constructs found in each transcript and make a holistic comparison between these numbers.

4 Empirical findings

This chapter presents and examine the empirical findings from conducted interviews. The findings are categorized according to the theoretical adoption framework. At the end an overview of summary of the findings is shared in the summary table.

4.1 Determinants of adoption

This section presents the determinants of adoption within the theoretical framework, categorized into innovation characteristics, external characteristics and organizational characteristics. These determinants are going to be presented according to the information analyzed from the interviews that were conducted.

4.1.1 Innovation characteristics

The innovation characteristics refers to innovation factors that drive or influence organizations to adopt IT, such factors include relative advantage, complexity and cost (Hameed et al., 2012). During the interviews, participants described some of the most important considerations driving adoption of analytics. However, it is noted that there are different perspectives of big data analytics adoption that are seen by interviewees as aspects to driving their adoption.

On one hand diverse advantages and opportunities were pointed out as relative advantage driving the adoption of big data analytics. Such advantages include the ability to analyze large volume of data, real time analysis and prediction. We found out that having the capabilities to analyze different data sources such as social media data can provide smart cities with information to understand better their citizens, and therefore make better choices on smart city solutions for resilience such as mobility planning and weather prediction. For instance, Björn Lahti explained how the city of Helsingborg collect information from all kind of systems that they can analyze and create useful information (I1-S31). This information is used by the management of the city in all levels so that they can see how the city is working and what they should do for the future (I1-S31). Peter Kisch explained how having access from different systems could improve the traffic of a city by providing insightful information to make better decisions, instead of just make infrastructure investments such as making roads wider, or introducing train lines without thinking if that is the best solution for the city (I3-S61). Likewise, Jonas Norman, described the relative advantages of using big data analytics to enable cities in implementing control mechanisms on the processes such as banning traffic during certain hours of the day to manage air quality (I4-S17).

When it comes to costs as influencing factors for adoption of big data analytics, we found out that the cost of adoption of big data analytics in smart cities can be high if it is not treated as a regional or national strategy. According to Peter Kisch, leaving the cities to invest and invent their own systems is going to be too expensive, especially for small smart cities (I3-S33). On

the other hand, Jonas Norman described that there is inadequate understanding in terms of how much should be invested and what is to be gained. This is mentioned to be a prudent factor in smart cities because they have fixed budget which needs to be split towards many areas in the city such as healthcare and education (I4-S66).

4.1.2 External characteristics

The external characteristics refer to the factors external to the organizational environment that must be considered when adopting a new innovation or technology. These external factors include pressure from partners, government support, partner's readiness and external pressure (Hameed et al., 2012). It was noted during the analysis of the collected data that all the interviewees acknowledge the importance of external players within the smart city context when deciding to adopt a new innovation.

One of our findings was the acknowledgement of the importance of finding ways for external parties to be interested on investing in developing services around the new technologies or innovations that are adopted within a smart city. For instance, Jenny Åström described how they are looking to attract investors by working with them as a company does, creating a business environment where both the municipality and third parties such as the real estate, property owners, and local businesses work together to develop the area (I2-S56). According to the interviewee, the main idea of this is to find ways for technical innovations to come together with social innovations to create value relations. For instance, if third parties invest in a technological innovation which would create social benefits for the city in a long-term, future projects and business development will give the investors the security of a long-lasting relationship.

When it comes to the specific case of adopting big data analytics, we found out that like any other IT innovation adoption, it is necessary to attract stakeholders interested on investing on it. For instance, Björn Lahti highlighted the importance of having external partners that help the smart city to make a better use of the data and the insights that can be generated by the use of analytics (I1-S39). He explained how the city of Helsingborg is facing problems due to lack of external parties that provide services from the data that is produced by the city (I1-S39). For this reason, it is essential to attract others to take part in providing services in order to succeed on creating insights in a smart city. In this context, Björn Lahti stated as following: "*[...] We have open, I think a lot of data in this city, but the ones surrounding us and the ones that could make use of this data to provide services (that we don't need to do them), they haven't found the data and they haven't really find a market yet, how to be successful in using the data in different ways to provide services for which they could earn money on.*"

We found out that it is also important to collaborate with private companies that are already in the market providing services for the city when adopting big data analytics for achieving smart city resilience. For instance, for the city of Helsingborg, Björn Lahti mentioned the mutual efforts for sharing data with different companies in the field of energy, utility management, and waste management in order to have a better knowledge of the city (I1-S13). Jonas Norman also emphasized on the possibilities of the collaboration with private companies such as car manufactures who have connected core systems with a lot of data that can be beneficial for the city (I4-S77). Other kinds of organizations such as national authorities and local businesses

were also pointed out as part of the sharing process, since they are the ones who will require access to the information produced by the city so that they can make use of it [I1-S37].
In addition, we identified the significance of including diverse companies that provide similar services for the city in a way that they work together instead of seeing each other as a threat. Peter Kisch explained that there are different businesses in the market creating a lot of solutions for the city without collaborating between each other because they are different organizations (I3-S9). In this scenario he suggested that big data analytics can play an important role by providing information to third parties where they can see their part of the pie, and therefore increase the level of trust by having a common way of understanding the needs of the city (I3S9, I3-S11). The idea is to empower external stakeholders to recognize their responsibilities and opportunities, where competitors can also see themselves as collaborators in order to create something that is much more suited for the citizens.

Another finding related to the key factors to be considered for achieving a resilient smart city is sharing knowledge and data with other smart cities. Jonas Norman explained the benefits of having many smart cities having a joint program when developing and implementing big data analytics so that they can share knowledge about how to operate the system better (I4S58). Björn Lahti explained the relevance of sharing data with other smart cities in order to understand more the citizens and improve the common services that the city provides (I1-S37). This is because citizens do not stay just in one city, but they are traveling through different cities during the day. In this context, Peter Kisch claimed the need of having solutions that embrace not just one smart city, but a group of smart cities in a regional level (I3-S63). Therefore, it is meaningful to consider an integrative plan to enhance cooperation and information sharing between smart cities.

Finally, we found out that the political influence and regulations play an important role when adopting big data analytics in smart cities. The interviewees exposed the need of presenting political benefits together with benefits of the technology in order to get the support from the political level in order to get investments. Jonas Norman explained this situation as follows: "[...] *The investment in cities is competing with schools, health care, traffic and the maintenance of street, there is a number of different posts and it is tricky for a politician to change priorities and introducing the concept of investing in a big data, then you will need to cut costs somewhere else*". Peter Kisch, on the other hand, commented this issue especially on cities as Sweden where the distribution of money come straight from the political assembly to the different departments of the municipality (I3-S28). For this reason, when politicians have to invest, they have to think it really well since they are representing a school or a hospital but they're also representing their political party and themselves (I3-S28).

4.1.3 Organizational characteristics

The organizational characteristics refer to the characteristics of an organization towards the adoptions of a new innovation or technology. There is a range of characteristics that must be considered within the boundaries of an organization such as readiness, top management support, IS infrastructure, culture, resources, just to name a few. While analyzing the data collected from the interviews, we identified that the organizational characteristics is the determinant with most mentions compared with the previous ones. Its importance is crucial when deciding to adopt new innovations.

While analyzing the collected data we were able to identify the importance of breaking silos in the smart city organization when adopting an IT innovation that will impact the whole organization. In this scenario, Jenny Åström mentioned the importance of having roles that are free and connected, which break silos within the smart city (I2-S30). Jenny Åström believes that in order to build a resilient smart city, able to manage new innovations, the communication between departments is crucial. Here, Peter Kisch explained how having departments which are unable to have an efficient communication, impacts negatively on the development of digitalization (I3-S28). In this context, Jenny Åström concluded that there should not be isolated processes, but processes that go through the whole organization in order to have a better panorama about the adoption of the new innovation (I2-S32).

In addition, we noticed that for the specific case of big data analytics the importance of communication within the boundaries of the organization and outside of it plays an important role. We found out that it is essential to think about having the same standards for data management across the whole organization. Björn Lahti pointed out that it is necessary that every department that produces data, considers the relevance of the data not just for its own department, but for all the organization (I1-S51). In this context, he was describing some of the problems that the city of Helsingborg is facing because of the difficulties in understanding the data between different areas of the city (I1-S51). For this reason, he stated that it is important to produce and maintain data, having in mind that this information could be of use to someone else within the organization and outside of it (I1-S51).

With regard to the limitations of the decision power and the independence of the smart city in a national level, it is important to understand how municipal organizations work. We found out that each country assigns different levels of independence to their municipalities which affects the way on how the adoption of new technologies should be treated and managed. Jenny Åström described a clear statement about this topic as following: "*[...] Municipalities in Sweden compared to other European countries and other countries in the world has much more power and much more independency compared to the state and the national level than in many other countries.*" This finding depicts that responsibilities are not the same for every smart city when adopting a new technology or innovation, which impacts on the complexity of the adoption process.

The previous finding goes hand in hand with the importance of working on the readiness of the organization. Jenny Åström described it as a challenge, which is being experienced by the city of Malmö. She explained that the city is not ready as an organization to start working with new innovations (I2-S64). She stated that despite the presence of policies and legislation that shapes the directions of the organization, it is not enough for a resilient smart city to be ready (I2-S68). In this context, Peter Kisch commented that the old idea of having independent departments in a municipality to ensure democratic influence, has ended with a very inefficient management, which affects directly on the development of digitalization (I3-S28). We found out that an important reason for the non-readiness of smart cities organization is that they present a silo structure that is not ready to adopt cross department technologies, such as big data analytics.

In this scenario, reorganization was pointed out an important aspect to be considered when adopting these kinds of technologies. In this context Jonan Norman explained that some cities have realized that the traditional way of organizing has to be changed in order to be able to implement a more digital way of working and have business processes able to take full

advantage of big data analytics and other digital tools available (I4-S55). However, he explained the complexity and the time required to do this due the elections period. He explained this phenomenon as follows: "[...] *We will have election this September you know, and maybe in a year or so they are established, the politicians with the new management relations and they can start to talk about reorganization. Then it will take a year to do that and then you need to agree maybe that this reorganization will take two years and you are already pass a new election. I think organization, is super important to make it work, but reorganization is complicated as well.*"

As part of the organization readiness, we were able to identify the support from the top management as one of the key elements to be successful in the adoption of big data analytics. We found out that it is vital to count with the support of the top management to avoid get stuck in all kinds of levels of the organization. Björn Lahti commented that for the case of the city of Helsingborg that being driven since the beginning by the top management was vital to establish a good readiness of the organization (I1-S68). In this context he explained as follows: "*[...] From starting, from about eight years ago, the top management have been selling us or they've been talking about this common vision we have in the city and we've been working with this on all kinds of levels*". In addition, we found out that in some cities it is important to include politicians as important actors in the top management decisions. In this context Jonan Norman claimed as follow: "*[...] I would like to include the politicians as the decision makers in the top management as well. It is important that they understand the need of investment and the volume of investment necessary to have a good data, but also from that investment to understand the value of the new solutions*".

When it comes to resources, we found out that it is important to consider not just a technical team that works with the adoption of big data analytics, but it is even more important to have all the organization making use of the benefits of the technology and try to create different usage of it. For instance, Björn Lahti mentioned that for the city of Helsingborg they count with a team of 12 people who are working with big data analytics processes such as data collection, processing, management and especially in exploring how this data can be used in different ways (I1-S29). Besides, he highlighted that despite they have people that know how to use the data they still need to spread more the knowledge so that more people are able to analyze the big data and make use of it (I1-S59).

4.2 Adoption process

The process of technology adoption within the theoretical framework consists of three factors which are the initiation, adoption decision and the implementation. These factors are discussed below in relation to our findings.

The initiation process looks at the underlying environment in which big data analytics gets adopted into the organization. In a practical sense, it starts with the awareness of the big data analytics technology, the attitude of the organization towards the new technology such as culture, top management support, proposal for adoption (Hameed et al., 2012). The adoption process looks at the whole process to adopt the technology such as allocation of resources (Hameed et al., 2012). The implementation part involves post-adoption that prepares the organization for use of the innovation looking at the extent to which the development, feedback,

and adjustment of innovation is carried out for the objectives of becomes ingraining the innovation into the organization settings (Hameed et al., 2012).

4.2.1 Initiation process

Interviewees acknowledged the importance of awareness of IT innovations in facilitating the design and implementation of the smart city resilience. This aspect was described from different perspectives by the interviewees. For example, Björn Lahti described the awareness of IT innovation in a way that it is used in the development of strategies. This was further explained that the awareness should not only look at the challenges and possibilities of the technology, but also as a new way of doing things (I1-S41). Additionally, awareness of IT innovation should focus on whether the innovation to be adopted is the right one. This means that the Innovation should contribute to creating the solutions that smart city needs to make it resilient (I2-S70). Similarly, Björn Lahti explained that not understanding the right usage of the big data analytics from the beginning can create future problems (I2-S55). For instance, for the particular case of the city of Helsingborg, Björn Lahti described how they are facing problems dealing with some providers for new requirements because they did not demand the right things from the inception of the adoption (I2-S55). He explained how they cannot use the data, locked by software providers, in other departments of the city without paying more money (I2-S55).

Analysis show that having a common vision and the awareness by top management and political leaders is also an important factor in the initiation process. This vision and awareness is discussed from the perspective of understanding the need for using big data analytics to improve service delivery and solving societal challenges by Björn Lahti (I1-S66). Björn Lahti, states that "*the top management have been selling us or they've been talking about this common vision we have in the city and we've been working with this and all kinds of levels*". Likewise, according to Jonas Norman, top management needs to understand the relative advantages and cost implications for adoption of big data analytics systems within smart cities. This is seen as of relative importance based on the factors such as fixed budget within smart cities (I4-S66). This as described by Jonas Norman can be achieved through having a vision and resilience targets are considered as components to enhance decision makers aware of the potentials of big data analytics (I4-S29).

We also found that in the initiation process, adoption of big data analytics should not focus on the technical aspects alone. The knowledge here is looked more of what are the challenges and needs, rather than focusing what is the solution. Jenny Åström describes IT innovation in this aspect as one of the solutions to solving these challenges and needs (I2-S6). Therefore, this describes that analytics as being one of the components to enhance smart city in solving various underlying challenges. Peter Kisch supports this statement by arguing that there is a need to find the match between the technical possibilities and what is really needed in the city (I3-S45). Therefore, this describes that it is important to know in advance what is the intention and the goals of the city, so that we can take full advantage of the technology to promote solutions that really address the challenges from the city.

4.2.2 Adoption decision

The adoption decision looks at the decision to accept the innovation adoption idea, evaluation of the idea and allocation of resources for adoption (Hameed et al., 2012).

Analysis shows that top management has influence on the adoption decision of IT innovation. According to the interviews, having top management support is vital in the adoption of big data analytics in smart city resilience programs. For example, Björn Lahti gives a description of this in this context, "*I don't know is the word is right but "vital", because if you don't have the top management. There are so many questions that get stuck in all kinds of levels…So I think it's vital for the success because one, one of the key things about this vision is in the mindset is you should do the right things*".

Another finding shows that there is a need of having a coordinating body that coordinates the adoption of technologies within the regional or national wide. In the description Peter Kisch stated that: "*[...] I think what is missing and what is for me actually pushing forward, is that you need to have some kind of coordinating digitalization unit*". Clearly, a coordinating body will act in pushing forward the adoption of big data analytics and coordinate the adoption among its implementing bodies such as smart cities and private companies.

We also found out that there is a lack of resources with the right skills to perform the required tasks to implement the adoption of big data analytics. In the case of the city of Lund, Peter Kisch explained that they are facing challenges on finding people with the right competence and knowledge in the municipality to proceed with adoption (I3-S57).

Moreover, evaluation of the adoption decision takes place in a collaborative manner as discussed by both Jenny Åström and Björn Lahti in a sense that not only the top management drives the way these solutions are implemented rather there being collaboration in efforts. Björn Lahti's expression to this is that "*[...] If you want something, do it, rather than who should do it, maybe someone else should do it or so. So from the top management we have this mindset that I can say that this needs to be done, then I do it. So that's how we have been working also with big data but other things as well in the Smart City to be able to do right things, not having the blessing for us from different levels"*

As part of the evaluation of IT innovation, we found that analysis of the innovation to be adopted should include a study of the external ecosystem instead of being analyzed in isolation. Jenny Åström described the importance of identifying the right stakeholders that will support the adoption of the innovation (I2-S70). It is mentioned that the right stakeholders must be considered together with the new innovation or technology before deciding to adopt it (I2-S70). In the case of the city of Lund, Peter Kisch commented how they are involved in small pilot cases in conjunction with companies such as the housing company or the energy company (I3S55). So, the main idea is to get to know the technology and acquire knowledge for the next step which is the real implementation of the solution.

4.2.3 Implementation

The implementation stage in adoption process, looks at preparation of the organization into adoption of the technology. Analysis showed that ingraining of the adopted technology into the organization through different data strategy and data management practices is practiced. Björn Lahti acknowledged that the city of Helsingborg has a strategy or way of doing things that guides implementation of adopted technology (I1-S25).

Additionally, the allocation of resources for the adopted technology is done through technical teams or departments that are dedicated to use the technology in implementing a certain smart city resilient program. For example, according to Björn Lahti, departments working with smart city resilience projects includes the geo-data or geographical information department. This department works with data and data management to see how it can be used in different ways. Another department works with collecting information from different systems like from the school or economics, the data is then turn into some useful information to the management of the city so that they can see how the city is working and what should they do (I1-29).

Another aspect in implementation as described by Jonas Norman, is that cities need to upgrade their processes in order to be more reactive to the result from analysis. In this context Jonas Norman explained as follow: "*[...] The big sort of challenge today, I think for many cities is not to gather information and do analytics. The big challenges are actually to upgrade their business processes to be more reactive to the result from analysis*". Not only should organizations upgrade processes, Jonas Norman (I4-S79) discuss that new business models can be developed to enhance cities make use of big data analytics. This is described to enhance smart city gain advantage through solving societal challenges using analytics.

The following section reviews how the experts in the field of big data and smart city resilience view the drivers and challenges for big data analytics adoption.

4.3 Key drivers and barriers for adoption of big data analytics for achieving smart city resilience

4.3.1 Key drivers for adoption

This section presents the findings about perceptions of interviewees related to advantages and opportunities of big data analytics in smart city resilience. From the literature review, some of these relative advantages include data sharing, ability to work with high volumes of data and improved decision making (see Table 2.2). From the interviews conducted, interviewees expressed different views and perceptions of the relative advantage and opportunities of this technology for achieving smart city resilience.

It is noted that that big data analytics offers ability for smart city implementers to share data and collaboration among different stakeholders such as other cities and private companies. This is done for different purposes such as to enable them to solve some of prominent challenges that can be encountered such as safety (I4-S43). Particularly in the aspect of safety, Jonas Norman describes that big data analytics gives smart cities the potential to monitor potential terrorist attacks, this is described as one of the most important aspect of analytics in many of European cities (I4-S43). To enhance data sharing, it was mentioned Björn Lahti that cities such as Helsingborg take advantage big data analytics solutions such as ETL (Extract, Transform and Load) to access data from multiple data sources (I1-S53). Björn Lahti explained the relevance of sharing data with other smart cities in order to understand more the citizens and to improve the common services that the city provides. This is because citizens do not stay just in one city, but they are traveling through different cities during the day. Therefore, it is necessary to share information between smart cities. But sharing should not be restricted to public organizations,

we found out that it is also important to cooperate with private companies when adopting big data analytics. For instance, for the city of Helsingborg, Björn Lahti mentioned the mutual efforts for sharing data with different companies in the field of energy, utility management, and waste management in order to have a better knowledge of the city. Finally, other kinds of organizations such as national authorities and local businesses must be also considered in the sharing process, since they are the ones who will require access to the information produced by the city so that they can make use of it.

Coupled with the above, Peter Kisch describes the potential of big data analytics in enhancing data driven information exchange. A typical example shared was the mobility system between the city of Lund and the whole region of Skåne. Analysis of data enables regions within Skåne to plan for routes for the cities and thus help cities overcome challenges related to mobility (I3-S9; I3-S61). Additionally, Jonas Norman describes the possibilities of big data analytics in this aspect of data driven information exchange, where organizations work together using data from the real time monitoring of noise pollution to implement various smart city solutions (I4-S79).

On the other hand, big data analytics provides cities with the ability to work with high volumes of data that is generated in smart cities for implementation of resilient programs. As indicated by Björn Lahti "*we working with also with how to take care of those things in the city, how to make the best use of data about the events and the weather. And when and where and what do they think in social media. What can we expect from that to make a better understanding for the choices we have*". This huge volume can be from various data sources such as social media data, and smart cities take the full potentials of big data analytics in making sense of these data sets to improve smart city solutions (I1-S31). Hence, big data analytics brings the opportunities for further development and innovations within smart cities in designing solutions such as smart city resilient programs. For example, the city of Helsingborg has a digitalization department working with what more they can do with the data (I1-S31).

Analysis shows that big data analytics enhances the ability of organizations to have knowledge about smart cities. The knowledge is then used in implementation of various resilient programs. Specifically, Jenny Åström, describes big data analytics and other technologies in smart cities as tools towards achieving resilience and sustainability. In addition to this Björn Lahti also describes how they use big data analytics in understanding the city, "*[...] And I think it's in many ways. We need to understand how the city works, how people travel, why and where the obstacles are for them, so so basically, in many ways, we're working with location based services or location based data*". In conjunction to this, big data analytics is used for improving decision making of various city challenges and issues. Björn Lahti mentioned that they use this technology to make use of the data that is available in the city such as data about the weather and what people think in social media. This is then used to enable them to make a better understanding for the choices they have.

Likewise, Jonas Norman describes that big data analytics has the potential to enable smart cities implement control mechanisms. This can enable smart cities not only to explore innovative ways to control the environment using big data analytics as opposed to just using the technology for monitoring purposes (I4-S15).

4.3.2 Key barriers for adoption

This section presents the findings about perceptions of interviewees about barriers of big data analytics in smart city resilience. Barriers in this context weaknesses and threats that hinder the adoption of big data analytics for achieving smart city resilience. From the interviews conducted, participant expressed different views and perceptions on this topic. Barriers that were discussed were looked form the organizational point of view and the technical point of view.
In the organizational point of view, one of the barriers as mentioned by Björn Lahti and Jonas Norman is the lack of knowledge and skills for big data analytics. This was based need to know more how to analyze the data and how to make the use of it. According to Björn Lahti, the challenge lies not in the technicalities of how to use the data, rather the ability to see how the data could be matched up with other things to provide a specific solution. This was also acknowledged by Jonas Norman who described that cities are only using the technology to monitor and reporting as opposed to taking full advantage of the technology features such as controlling, "*[…]and they don't know about yet how to act on that. It will still be just a monitoring not the controlling system. For me, the thing with big data would be that you actually can use the information to sort off control your processes*".

Moreover, the inadequacy in the legal and regulatory provisions enforcing data management are also described as organizational challenges. According to Peter Kisch, the existing polices have not adopted to the innovations that the technology brings (I3-S24). In this aspect Jonas Norman shares the experience existing legal and regulatory setting limits the sharing of data within smart cities and private companies (I4-S77). Therefore, the smart city and national governance systems are not adapted to the new big data possibilities (I4-S77). This is largely described by Jonas Norman that private companies have the data and the willingness to share data however smart cities response is too slow and problematic due to regulations and structures (I4-S77). In addition to this Peter Kisch highlights that the availability of a national strategy or a regional strategy to coordinate the adoption is missing (I3-S33). On the other hand, being too careful results organizations into doing nothing, because of the regulations being too tough (I1-S70).

Lastly, on the organizational barriers is the inadequate organizational structure. Based on the discussions that adoption of big data analytics requires reorganizations (I4-S55). It is discussed by Jenny Åström and Jonas Norman that reorganization of city or municipality is a complicated process, and this delays the implementation of the new adopted technology (I2-S32; I4-S77).

The technical barriers include inability to produce and provide data for others to use. This was mentioned to be caused by various factors that include vendor lock in thus causing inability to integrate data sources from these systems and also at times required to pay the vendors more to enable access to some services (I1-S55). Another cause as mentioned in conjunction to this, is the challenge of software incompatibility and unlocking data in some systems (I1-S55). In the end, this hinders data exchange in some of smart city solutions.

Data quality was also an aspect that was widely discussed as a technical barrier by Björn Lahti for the city of Helsingborg. In this aspect the quality of data is seen to be a challenge for example when working with data that may not have the attributes required for different usage. This can be caused by the fact that the data owners may simply not want that data and in that case, not collect it (I1-S47).

In case of security threats and risks, Björn Lahti and Peter Kisch acknowledged the existence of this challenge and the vital need to protect data. To ensure security of data, Björn Lahti mentions that they are working to ensure integrity of their database, this also includes working with various solution provider vendors such as Microsoft to ensure they are updated with new threats and risks and effective measures are taken. As Björn Lahti mentioned in the city of Helsingborg, "*But we can't say that the regulations or security should block us from doing those things we need to do it anyway. But we need to be careful and also have this also I think it's more mindset of knowing more about data and the risks of data and in the correct integrity questions around data*". Therefore, it is more of taking effective measures rather than making it a hindrance towards implementation.

Additionally, when it comes to data privacy, analysis show that there is acknowledgement of this barrier in adoption of big data analytics. For example, Björn Lahti agreed that there is collection of personal information such as social security numbers and that organizations needs to be careful while handling users' information and also there should be room to learn in order to improve management of data privacy (I1-S70). On the other hand, Jonas Norman also shares that that capabilities of big data analytics pose privacy concerns particularly when they are applied in enhancing cities handle security monitoring for terrorist attacks (I4-S87). In this case user information is manipulated such as facial recognition, monitoring of key words in conversations and others.

4.4 Summary of empirical findings

In summary analysis shows that in the determinants of adoption, the innovative characteristics include: relative advantage of big data analytics for achieving smart city resilience, complexity and cost of adoption. The external characteristics include: acknowledgements for finding ways for external parties to be interested in investing for smart city resilience, attraction of stakeholders, collaboration and role of political influence and regulations in adoption. The organizational characteristics include: breaking silos in the smart city organization, communication within the boundaries of the organization and outside, organizational structure of smart cities, organizational readiness and resource allocation for adoption.

In the adoption process, initiation considers: awareness of IT innovations in facilitating the design and implementation of the smart city resilience, having a common vision, awareness by top management and political leaders and knowledge of challenges in the city and technical possibilities. The adoption process considers: having top management support, having a coordinating body, having the right skills, collaboration for evaluation of adoption and analysis of external ecosystem for instead of isolated analysis. While the implementation process considers: data strategy and data management to guide the way of doing things (Adoption), having dedicated departments for adoption, upgrade the business process and develop new business models.

In the key drivers for adoption, analysis shows that: data sharing and collaboration, data driven information exchange, work with high volumes of data, opportunities for further development and innovations, ability of organizations to have knowledge about smart cities and Implementation of control mechanisms on smart city process. Key barriers in the organizational context includes: lack of knowledge and skills for big data analytics, challenges in upgrading

business process, inadequacy in the legal and regulatory provisions enforcing data management and inadequate organizational structure. Technical barriers include: inability to produce and provide data for others to use, data quality, security threats and risks and privacy.

5 Discussion

In this chapter the empirical findings are discussed in the context of the underlying research questions and theoretical framework. The similarities and divergence of empirical findings from the theoretical framework are discussed in order to refine the theoretical framework but also to contemplate on why these research findings were generated. This chapter begins with discussions on the findings in relation to the theoretical framework. The chapter then concludes with a new iteration of the framework as a result from comparing the theoretical and empirical findings to frame the most predominant drivers and barriers towards big data analytics adoption.

5.1 Determinants of adoption

5.1.1 Innovation characteristics

Within the literature review, in the section 2.7, it was possible to identify some of the innovation factors that influence the adoption of IT in organizations such as its relative advantage, the complexity and the costs involved. When it comes to the relative advantage, the wide range of the applicability of big data analytics in different areas of a resilient smart city such as energy, safety, mobility, healthcare, just to name a few, was presented and described. The complexity of some aspects such as the data integration and security were mentioned as a challenge plus the limited access to information collected by private companies. The high cost of investing in IT professionals, consultancies, training and data processing was also reviewed and described when presenting our theoretical framework.

Our findings about the innovation characteristics of big data analytics corroborate its benefits for achieving smart city resilience. Its application in diverse smart city components such as mobility, energy and safety were experienced and explained by the interviewees. Its capabilities for analyze big amounts of data, sharing information, monitoring, just to name a few, depicts the factors related with the relative advantage of the adoption of this technology. Besides, we argue that the relative advantage should not rely on the technology applications and benefits. It is crucial to analyze if the IT innovation to be adopted is the right solution for achieving smart city resilience, depending on the specific needs of the city and the environment around it. We disclose the importance of recognizing in advance the right stakeholders that will support the adoption as part of the identification of the relative advantage. This was absent in the IT innovation adoption theory which situates the evaluation of external stakeholders in a more advanced stage of the adoption process.

The findings revealed the challenges that smart cities face with technological lock-in. Dealing with software providers for unlocking data can results in additional investments. But costs are not just related to technology, a lack of a regional or national strategy for adoption of technologies in smart cities can bring high costs for the municipalities, especially for the small ones. Besides, we identified the importance of determine the possible uses of the data and

acknowledge the importance of data quality within the departments of any smart city. This coincides with what was reviewed in our theoretical adoption model as factors to be considered as part of the innovation characteristics.

In short, the relative advantage and the benefits of the adoption of big data analytics for achieving smart city resilience is proven. The high costs that this adoption can bring can be higher than expected if the requirements are not defined correctly before the adoption and if it is not treated as a regional or national strategy. The characteristics of big data analytics and the ecosystem of services around it must be acknowledged and considered in an early stage of the adoption. Finally, the data quality and the usage of data must be identified in diverse areas in order to fulfill the requirements of the resilient smart city.

5.1.2 External characteristics

The literature describes external factors such as pressure from partners, government support, partners' readiness and external pressure that must be considered when adopting a new innovation or technology (Hameed et al., 2012). Our findings support these affirmations and expand them further. Indeed, we found out that one of the most important factors to be considered for achieving smart city resilience is sharing data with public organizations and private companies. We also found out that it is essential to consider other smart cities as external partners. For this reason, we claim that the adoption of big data analytics for achieving smart city resilience goes beyond the boundaries of a single smart city.

Another topic reviewed is including collaboration with external companies and acknowledge their readiness when deciding to adopt a new technology or innovation. This is supported by our findings where we identified three main aspects to consider:

- It is decisive to attract external parties to be interested in investing in developing services around the new technology adopted.
- It is important to strengthen the cooperation with private companies that are already in the market in order to have a better understanding of the city and generate meaningful insights to support the smart city resilience.
- It is relevant to include diverse companies that provide similar services for the city in a way that competitors can also see themselves as collaborators in order to create solutions more suited for the citizens.

For this reason, it is essential to support third parties to motivate them to invest in the field. This can be done by giving them facilities to understand and access the data generated by the city. Besides, providing information to third parties where they can see their part of the pie is essential to increase the level of trust among companies. Additionally, a long-term relationship could be created by giving third parties the opportunity to generate social innovations that allow them to expand their business.

The political influence and regulations are important external characteristics to be considered when adopting big data analytics. It is a substantial matter to understand that it is required to go beyond the benefits of the technology adoption when presenting it to politicians. Political

benefits are required especially when the structure of the smart city organization is tightly related to the political influence. When it comes to regulations, it is important to enforce data policies in order to take advantage of the data generated by external companies. The smart city and the national governance system of data verification has to be contemplated in order to avoid barriers that can undermine the successful adoption of the technology.

In summary, the external characteristics are an important aspect to deal with in the process of adopting big data analytics. There is a variety of external stakeholders that must be considered when deciding to adopt a new innovation for achieving smart city resilience. It is essential to call the attention of businesses to invest in providing services for the city to create insights so that big data analytics processes are accomplished. Besides, it is important to recognize the diverse organizations that are already working in diverse smart city components, and work together to make better use of the data generated by them. Finally, it is essential to consider the political influence and the regulations related to data policies that can affect the adoption process.

5.1.3 Organizational characteristics

The literature describes the organizational characteristics as a set of factors to be considered within the organization towards the adoption of a new innovation or technology (Hameed et al., 2012). Diverse factors were mentioned such as readiness, top management support, IS infrastructure, culture, resources, just to name a few. Our findings support what was proposed in the literature, positioning the organizational characteristics as the determinant with most references compared to the innovation and external characteristics.

When it comes to the organizational readiness, we found out that the communication between departments is crucial. In order to achieve this, smart city must have a structure that allows it to break the silos and therefore be more connected. It is also important to consider having cross department processes that favor a smooth adoption of the new technology. In this scenario, reorganization might be considered since the traditional old way of municipalities structures might not be able to support a more digital way of working, with processes able to take full advantage of big data and analytics. When it comes to big data analytics, it is essential to ensure a correct data management and quality, to design standards shared across the whole departments of the smart city. The organizational culture plays an important role here since every employee of each department has to internalize the idea that the data and the insights that they are producing are relevant not just for its own department, but for all the organization.

One of our findings showed one aspect that was lacking in the literature of organizational characteristics which is the consideration of boundaries of the decision power of a smart city. It is essential to acknowledge how municipal organizations work in the country where the smart city is situated. This is because the level of independence of municipalities is variable, which can affect the big data analytics adoption process. In the specific case of Sweden, we saw how this influence the way on how the adoption of new technologies are treated and managed. Therefore, the boundaries of the responsibilities of the smart city represent an important organizational characteristic that must be analyzed before the adoption of any technology to avoid getting stuck in the middle of the adoption process.

The top management support was cited from the literature as one of the factors to be considered as part of the organizational characteristics. Our findings corroborate this statement and reveal that this is one of the most important factors for being successful in the adoption of big data analytics. Being driven from the beginning by the top management allows spreading the adoption through the whole organization in all kind of levels which promotes the usage of data in different smart city components. Besides, it is relevant to acknowledge for some cities the influence of politicians as the decision makers in the top management.

Resources were also mentioned in the literature as essential for the adoption of big data analytics. We were able to verify the importance of this factor after our analysis, but we found out that technical resources are not the only ones to consider. Resources from different parts of the organization who make use of the data are needed, people who are able to analyze the big data and create diverse usage of it.

In summary the organizational characteristics plays a crucial role in the process of adoption of big data analytics. There are plenty of factors that must be considered. When it comes to the organizational readiness and culture, we identified the importance of having a structure able to break silos, having cross department processes that support the adoption process, consider data management and quality standards shared by the entire organization and design an organizational culture so that different areas produce information having in mind its importance for the whole organization. The support of decision makers in the top management and the political level was also pointed out as an important factor. Finally, the human resources embrace not just technical people but people across the organization able to analyze and make use of the data generated.

5.2 Adoption process

5.2.1 Initiation process

In literature review (Hameed et al., 2012), the process of adoption of innovation within the organization is categorized as a stage-based process. In particular the initiation stage of technology adoption is mentioned to pass through the awareness of innovation, formation of attitude towards innovation and proposal for adoption.

An observation from the findings revealed that the organizational practice is not far from the literature. Findings show that there is awareness of what big data analytics technology is and that it is used by several departments within their organizations or within the cities implementing smart city resilient programs. However, findings shows that awareness of technology is not the only factor of adoption in the initiation stage. The knowledge of challenges and requirements from stakeholders is also mentioned as a key factor in technology adoption where these smart cities see technology as a means to an end and not an end itself.

In the formation of attitude towards adoption, findings show that having a common vision is an important factor to drive big data analytics adoption for smart cities resilience. The vision is described as an incentive towards adoption and also a driving force towards formation of attitude for adoption. In addition to this, awareness by top managers and political leaders on

aspects such as what is the cost for adoption, what are the capabilities of the technology in achieving smart city resilient targets, promotes adoption.

In summary, the initiation stage is then considered to consisting of awareness of the smart city challenges and requirements supplemented with knowledge of big data analytics capabilities to achieve the requirements. Besides, the initiation process includes having a common vision that drives smart cities towards adoption of big data analytics for design and implementation of smart resilient solutions. Likewise, the awareness by top management and political leaders of the incentives for adoption plus the awareness of capabilities of big data analytics as one of the solutions in the design and implementation of smart city resilience programs.

5.2.2 Adoption decision

The decision to adopt is also one of the stage-based processes of adoption of technology. According to (Hameed et al., 2012), this stage reflects the decision to accept the technology, evaluation of proposed idea from various perspectives such as technical and allocation of resources to adopt the technology.

From the findings, a decision to accept the technology is mentioned to be driven by having top management support. It is vital that the top management to have awareness of the relative advantages of the technology and in support of the common vision for adoption. Moreover, top management in this aspect is extended to include political leaders since they also play a role in the decision making.

In the aspect of allocation of resources, findings show that the smart cities have dedicated departments that are working with big data analytics for implementation of resilient programs. These departments work with big data to provide various smart city resilience solutions. Another aspect includes having the right skills within the smart cities to ensure effective adoption of the technology. Skills here include the ability to have innovative solutions on what to do with data as opposed to using the available data from analytics for reporting and monitoring alone.

Having a coordinating body is an important factor to steer the adoption of big data analytics particularly in small cities. This aspect is also discussed to influence sharing of effort and costs for implementation of smart city solutions.

On the other hand, the evaluation of the decision to adopt the technology should include an analysis of external stakeholders instead of focusing on isolated analysis, this will improve the aspects of collaboration. Similarly, evaluation within smart cities should include collaboration for evaluation of adoption as opposed to top management dictating what should be done.

5.2.3 Implementation

The other stage in the process of adoption is the implementation stage. This stage, according to literature involves preparation of organization for use of the innovation.

An interesting finding from the smart cities interviewed is that, apart from having dedicated departments that are working with big data analytics as previously described. It was noted that

the availability of data strategy and data management practices guides the implementation of adopted technology. Having data strategy is discussed in literature as an important component towards making these cites able to have the right resources to support the transition towards adoption and implementation.
The importance of business process upgrade and the need to develop new business models is discussed in the findings. Business process upgrade enables organizations to adopt new way of doing things without delay.

In summary the implementation stage is characterized by the dedicated departments working with big data analytics solutions and the data management strategy to guide implementation, upgrade of business process and the development of new business models.

5.3 Key drivers and barriers for adoption of big data analytics for achieving smart city resilience

5.3.1 Key drivers for adoption

In literature review, key drivers are derived from the opportunities and strength that big data analytics technology has in influencing smart city resilience. These key drives include but not limited to real time analysis and prediction, data sharing, collaboration and knowledge base for smart cities. The empirical findings from the smart cities are not far from this, however not all of the key drivers from literature were perceived as drivers towards adoption.

One of the emergent drivers is the ability of big data analytics to enhance data sharing among implementing stakeholders. The aspect of data sharing is discussed in literature were data analytics plays a role in enhancing efficient smart city planning and development of resilient programs. From the findings, the use of technologies such as ETL facilitates use and sharing of data from various data sources.

In conjunction to the above discussion, findings also show that big data analytics enables smart cities to work with high volumes of data that is generated in smart cities for implementation of various smart city resilient programs. There is correlation of this aspect to literature (see Table 2.3), where discussions of big data analytics in smart cities, show how data related to environmental conditions can be analyzed for disaster response. This data can be from sensor networks measuring air pollution, energy consumption, water levels, or seismic activities.

Findings also show that through big data analytics is possible to create knowledge about smart cities. This is mentioned to be vital in implementation of smart resilient cities programs such as resilient programs and service provision. Literature describes this in detail by acknowledging that processing of multiple diverse data sources distributed among connected entities in smart cities creates a knowledge base for a smart city. Through this knowledge, planning and investigation of particular aspects of city life and changes that are happening over time is done. In the end organizations build predictive models with respect to everyday life in the city for management and development of effective plans such as plans during flooding, manage public behavior during crisis or monitor the cities against terrorist attacks.

On the other hand, findings also show that big data analytics technology improves decision making for various city challenges. This is in conjunction to literature is an important attribute in big data analytics. A particular example is of this in relation to smart city resilience is the use of tools such as geovisual analytics which not only creates situation awareness but also facilitate effective decision making.
An additional advantage of big data analytics is described as the potential to equip cities with the ability to control processes. This is potential when it comes to resilience since it provides the smart cities to be flexible and adaptable to challenges.

5.3.2 Key barriers for adoption

Barriers of big data analytics from literature review are derived from the weaknesses and threats for big data analytics adoption in the context of smart city resilience. From the literature review, these include: making meaningful from data, Inadequate legal provisions to enforce data policies, capacity to utilize data within smart cities, silos and lack of data integration, data challenges, process challenges, high cost, inadequate data governance, inadequate skills, security threats and data privacy. The overview of barriers from the findings revealed that organizational barriers that are due to technical reasons and due to organizational reasons as further discussed below.

On the organization perspective, findings show that one of barrier is the inadequate knowledge big data analytics, in the context of how to analyze the data and make use of the data including matching it up with other things to provide specific solutions. This according to literature is a challenge as well particularly in mining patterns from the city data and make useful decisions with it. This is also seen from the inadequate capacity of city planners for smart city to utilize data and have useful insights that will hence be used in the planning and designing of resilient programs for smart city resilience.

Technical challenges from the findings include challenges of producing and providing data for others to use. This is mentioned to be caused by various factors such as technology lock in, software incompatibility and inability to access data from some of systems. In the end this hinders data exchange and access. In literature these challenges are also widely discussed, for example traditional data storage and processing systems are facing challenges in terms of performance, scalability and availability of big data. Another view of this challenge is in the delay of fetching data from systems with big data due to remote location of storage devices or due to geographical constraints thus limiting data access. Also, literature acknowledges that there is technological lock in from some of smart city systems and solutions.

Both literature and findings show that data quality is also mentioned as one of the technical challenges in the adoption of big data analytics for smart city resilient implementations. Specifically, data quality problem is discussed from the findings in the aspect that data is only understood by data owners or those working with that set of data. Subsequently, these data sources cannot be understood by other parties who wish to use the data, also at times attributes you are looking for are not available because they were not collected by the data owner.

Another crucial barrier from the findings is the aspect of security threats towards the big data. The existence of security threats that affect smart city resilience in big data analytics is widely discussed in literature (Al Nuaimi et al., 2015; Chauhan et al., 2016; Kitchin, 2014) where the

accumulation of large sets of data is mentioned to attempt cyber attackers. Attack on data infrastructures can affect the city infrastructures and affecting its ability to become resilient. Based on criticality of security of data and its infrastructure it was discussed in findings, smart cities are working with vendors to ensure that they are updated and also working to ensure their systems are secure.

According to literature to Philips-Wren et al. (2015) there is not type of framework for big data governance strategy able to fit with configuration of specific smart city. This represents a challenge particularly to adoption because smart cities are the not able to upgrade their processes and structure to deal with the new business models under big data analytics, as a result the challenge of silos implementations and the inadequate sharing of data within smart cities and private companies has been discussed.

In the aspect of data privacy, it is identified in the findings and literature that smart cities ubiquitously collect information about people, places and activities. This can be for the intent to provide more understanding of the city, improve service delivery or facilitate monitoring security. However, this process poses the challenges of privacy especially in management of user data. As a result, this is seen to hindrance factor to adoption in a sense that some cities become too careful and resulting them into doing nothing because regulations are being too tough. Concerns such as that of violating citizen privacy particularly because of sharing personal information to external parties in smart cities are likely to occur. Generally, the privacy problems as perceived in findings fits well as one of the threats as discussed in literature (Hiller & Blanke, 2017). Moreover, it supports the challenge of making use of data while preserving privacy which is the real kernel of the problem partiality in big data analytics.

5.4 Summary of the discussion

Both the empirical data and the literature review indicate that big data analytics has potential to facilitate design and implementation of smart city resilience programs, this is evident from literature review, empirical findings and discussions. To aggregate these discussions, the results of the study are presented in the following section. These results are based on the research question of this thesis:

What are the key drivers and barriers towards big data analytics adoption in smart city resilience?

In order to answer the question, we will investigate and analyze the following:

- How is the adoption process of big data analytics for achieving smart city resilience?
- What are the drivers and barriers when adopting big data analytics in smart city resilience?
- How big data analytics is applied in the smart city resilience process?

Table 5.1 below provides summarized answers to the above questions, by presentation of factors that affect the adoption of big data analytics in smart city resilience.

Table 5-1: Summary of the findings in the discussions

Determinants of Adoption

INNOVATION CHARACTERISTICS

- **Relative Advantage**
  - Identify if the technology fulfills the specific needs of the city
  - Identify the presence of stakeholders in the market able to support the adoption.
  - Take advantage of big data analytics capabilities described as the "drivers" towards the adoption.
- **Complexity**
  - Deal with technological lock-in.
  - Lack or regional or national strategy to support for big data analytics adoption in smart cities.
  - Deal with data quality from both internal and external parties.
  - Deal with additional investments due to unclear requirements.

EXTERNAL CHARACTERISTICS

- **Investors to extend the smart city services**
  - Call the attention and motivate businesses to invest in providing services for the smart city.
- **Companies already working with smart city components**
  - Identify organizations already working with diverse smart city components and strengthen the relationships to make better use of the generated data.
- **Political influence**
  - Consider the political influence when presenting the adoption of the technology.
- **Regulatory entities readiness**
  - Acknowledge the readiness of the entities in charge of regulations related with national data policies.

ORGANIZATIONAL CHARACTERISTICS

- **Organizational Readiness**
  - Have a structure able that break silos.
  - Have cross department processes to support the adoption process.
  - Have data management and quality standards shared by the entire organization.
  - Encourage an organizational culture able to acknowledge the information produced matters for the whole organization.
- **Top Management Support**
  - Count on the support of the top management and key decision makers such as politicians
- **Resources**
  - Consider not just technical people for the implementation of the solution, but people able to analyze and make use of the data.

Adoption decision

INITIATION PROCESS

- Awareness of IT innovations in facilitating the design and implementation of the smart city resilience Having a common vision
- Awareness by top management and political leaders
  Knowledge of challenges in the city and technical possibilities

ADOPTION DECISION

- Having top management support
- Having a coordinating body
- Having the right skills
- Collaboration for evaluation of adoption
- Analysis of external ecosystem for instead of isolated analysis **Implementation**

- Data strategy and data management to guide the way of doing things (Adoption)
- Having dedicated departments for adoption
- Upgrade the business process
- Develop new business models

Key drivers and barriers for adoption

Key drivers for adoption

- data sharing and collaboration
- data driven information exchange
- work with high volumes of data
- opportunities for further development and innovations
- Ability of organizations to have knowledge about smart cities.
- Implementation of control mechanisms on smart city process

Key barriers for adoption

- **Organizational barrier**
  - Lack of knowledge and skills for big data analytics,
  - Challenges in upgrading business process,
  - Inadequacy in the legal and regulatory provisions enforcing data management and
  - Inadequate organizational structure.
- **Technical barrier**
  - Inability to produce and provide data for others to use
  - Data quality
  - Security threats and risks,
  - Privacy

6 Conclusion

This chapter concludes from the empirical findings and its discussion in order to outline the central findings of this study as shared in the summary. The chapter also gives suggestions for future research.

6.1 Research Purpose and Findings

The purpose of our research was to identify the key technical and organizational factors towards the adoption of big data analytics for achieving smart city resilience. In accordance to this aim, we presented a compiled theoretical framework to help us identify these factors by grouping them in three main components: The key drivers and barriers for adoption, the process of adoption and the determinants of the adoption. Through our empirical findings and analysis, most of the factors that were identified in our compiled theoretical framework were also discussed by expert, moreover we were able to disclose new factors. Research revealed the identified key factors for adoption influence each other and hence there is an interconnection between them.

As part of the determinants of adoption, the organizational characteristics play a crucial role in the adoption process. The organizational readiness is one of the most important factors to be considered in this category and it faces diverse challenges through the adoption process. The top management support is also a key factor to look at. Counting on the support of the top management is crucial for the successful adoption of big data analytics. Last but not least, the resources are also considered as an important factor that focuses both on technical and business people in order to achieve a successful adoption.

Research identified that when it comes to the external characteristics as influencers of adoption of big data analytics, the key factors here include having investors to extend the smart city services and it is important to strengthen collaboration with private companies and other smart cities to support the smart city resilience. It is essential to also consider the political influence and the regulations related to data management that can affect the adoption process.

In the innovation characteristics, the key factors for adoption of big data analytics for achieving smart city resilience are identified from the relative advantage of big data analytics. This is interconnected to key drivers for adoption and includes: identification of the needs of the city and stakeholders to support the adoption and taking advantage of big data analytics capabilities. The complexity and costs for adoption are linked to the key barriers for adoption. These barriers are viewed from the technical and organizational perspective. The technical barriers include privacy, security, data quality and the inability to produce and provide data. The organizational barriers are those related to lack of knowledge and skills for big data analytics, challenges in upgrading business process, inadequacy in the legal and regulatory provisions enforcing data management and Inadequate organizational structure.

On the initial stage of the adoption process the awareness of the capabilities of big data analytics, having a common vision, awareness by top management and political leaders and knowledge of the challenges in smart cities are considered vital for adoption. The decision to adopt is influenced by the organizational characteristics such as top management support, having the right skills to drive the adoption particularly within the smart cities. Others include having a coordinating body at the regional or national level, collaboration for evaluation of the adoption and analysis of external stakeholders instead of isolated analysis. The implementation of adoption factor includes upgrade of business process, development of new business models, having dedicated departments for adoption and having data strategy and data management to guide the new way of doing things.

6.2 Implications for future research

The research was limited to smart cities within Sweden, however as suggested by Chauhan, Agarwal, and Kar (2016), challenges within smart cities vary from city to city. Other cities might face specific challenges due to its size, cultural and political influence. Therefore, we are suggesting conducting more research in other smart cities to make the understanding of factors for adoption of big data analytics relevant and applicable to the domain of study for the particular smart city.

Consequently, we suggest that more interviews can be conducted with experts both within the implementing smart cities and external stakeholders working with these smart cities in achieving smart city resilience. This will make the study more exploratory with new factors for adoption of big data analytics for achieving smart city resilience.

Lastly, this research is limited to adoption of big data analytics at the organizational level, the inclusion of the individual level of the from the study by Hameed, Counsell and Swift (2012) can be performed to explore more on the individual characteristics such as acceptance of technology and how they affect the adoption of big data analytics for achieving smart city resilience.

Appendix

Appendix A- Interview Guide

The interview guide outlined below consists of semi structured interview questions that were used during the interviews.

Research Introduction

This interview guide is part of the master's thesis study that is written in the department of Informatics at Lund University. The purpose of this study is to investigate what are key drivers and barriers towards big data analytics adoption in smart city resilience.

- ❖ indicates a supplementary question to a certain theme
- ➢ indicates a question that gives more clarification to a theme question

Introduction questions.

1. Could you please give us an overview of your experience and background?

Interviewee understanding of the topic

2. How would you describe your familiarity with big data analytics technology?

3. How would you describe your familiarity with smart cities resilience?

4. How would you perceive the concept of big data analytics for achieving a resilient smart city?

Big data analytics in smart city resilience process

5. **Theme:** Organizational characteristics in adoption of big data analytics against big data for enhancing smart city resilience

   - ❖ What smart city components (energy, mobility, housing, etc.) do you consider is being included in your organization?
   - ❖ What was the organizational incentive to adopt big data analytics solutions (what was the business case?)
   - ❖ How does the organization you work for, execute big data analytics against big data for enhancing smart city resilience?
   - ❖ How do you consider the top management support for the initiatives of adopting big data analytics?
   - ❖ How important do you consider data management and governance in big data analytics? (e.g. what management tools are available)
   - ❖ How ready was the organization to adopt big data analytics (e.g. Training, resources, culture, IS infrastructure, capacity to utilize data)?

- ❖ How important is collaboration and data sharing between smart city systems for interoperability and knowledge sharing?
- ❖ Could you describe your experiences in some of the projects you have been involved in? (smart city resilient projects)

6. **Theme:** External characteristics in adoption of big data analytics against big data for enhancing smart city resilience

- ❖ To what extent do you think external influences (stakeholders) has contributed to big data analytics adoption?
- ❖ Who are the stakeholders involved in implementation of the project (s)?
- ❖ How can you state external stakeholder's readiness in terms of data access and collaboration?
- ❖ How do you manage data access and knowledge sharing between these stakeholders?
- ❖ What are the purposes stakeholders are considering, when implementing a big data analytics solution?

7. **Theme:** Innovation characteristics in adoption of big data analytics against big data for enhancing smart city resilience

- ❖ Where do you think are the main challenges of adoption of big data analytics for achieving smart city resilience?
  - ➢ Can you give a concrete example from your experience?
- ❖ How do you perceive the complexity of handling big data analytics concerning tools, compliance or scalability?
- ❖ To what extent does technical uncertainties towards big data analytics adoption affect smart city resilience? (such as security of data, data integration, unstructured data, privacy of users)
- ❖ How does your organization deal with cope with the often-mentioned issues?
- ❖ Is there any impact of big data analytics on internal and external processes and relationships?

Ending questions

8. Is there anything you would like to add?

9. Could we use your name and the name of your organization in the thesis?

Appendix B- Interview with Björn Lahti

Organization (smart city): Helsingborgs stad
Place and date: Helsingborg, Lund, 30 April 2018
Duration: 37 minutes
Type of interview (phone, skype call with video, in person): skype call
Name of the interviewee: Björn Lahti
Job title of the interviewee: Program Manager Smart Helsingborg
Name of the interviewer: Victor Zanabria, Dianah Mlokozi

VZ = Victor Zanabria, **DM** = Dianah Mlokozi, **BL** = Björn Lahti

[S1] VZ: So Diana will start with the questions, if you have any doubt or any questions you can just let us know and we will keep the questionnaire going on.

[S2] BL: Yeah that is fine. If I can't find the right word in English is okay in Swedish or... surely it will work.

[S3] VZ: Yeah. It's okay. Don't worry, or we'll find a way to explain that in other words, it's fine.

[S4] BL: Yeah, you might translate it on the recording.

[S5] VZ: Yes, yes, yes.

[S6] DM: Okay, Bjorn, this is Diana.

[S7] BL: Hi.

[S8] DM: Okay. I could, first ask you to give us an overview of your experience and background just a little bit so that we know you.

[S9] BL: Yes, yes. I've been working with the digitalization and one can say smart cities as well for very long time and the city of Helsingborg mainly based on data and systems and capabilities like in geographic information systems. So my background is that I'm civil engineer. So that's my, where I started out, but I've been working with the digitalization of the cities. Now it's more more in the city not in digitalization only. In the areas of those working with the city. So yeah, a long time experience. Okay.

[S10] DM: Perfect. Okay. So in that sense, we will also wanted to know your familiarity with big data analytics technology and the aspects of smart city resilience to your knowledge. What do you understand of these concepts.

[S11] BL: I think understand them. Well, I'm not I'm not the expert that are doing these things I'm more working with strategies and looking into the future and to see what this what are what

are our challenges, what are the possibilities, mainly in technology, but also in other ways how to do things. So I think I understand them quite good.

[S12] DM: Okay, now I'll ask you what what Smart City components is your organization working with in terms of maybe you are focused on energy or mobility, housing in that aspect?

[S13] BL: What my company or other companies I work with? I didn't understand the question because because working in the city, we have a lot of different business cases or I don't know the word sections working with different parts in in providing the city services. So we have the energy company working with them, but they are working on their own and been working together in cooperation and also the utility management companies also waste management and everything, so I try to manage or connect all city services, whether it's based from the municipality or the municipality own company, so we have a lot of smart city companies that we are working with. That's the answer.

[S14] DM: Yes that that's the perfect answer because we just wanted to know in which aspects do you focus on one project or you have multiple projects.

[S15] BL: I have multiple projects, because I'm working more with the mindset, how to do things and what are the capabilities we need to expand and do better to have the possibility to be a smart city in every aspect.

[S16] DM: Okay, so can you maybe describe to us like how your organization execute big data analytics against the the type different big data that is collected on these smart cities?

[S17] BL: How we use big data, or could use big data.

[S18] DM: Yes, you could yes

[S19] BL: Could, okay, being able to to improve the services for the citizens, for the companies and businesses in the city. We need to make better use of big data, and I think it's our data in a way.

[S20] DM: Yes.

[S21] BL: And I think it's in many ways. We need to understand how the city works, how people travel, why and where are the obstacles for them, so so basically, in many ways, we're working with location based services or location based data. So I don't know if I can answer the question, but we are working with with looking to see usage in different areas.

[S22] DM: Okay, so Okay, I think

[S23] BL: I'm not saying specifically with one but we working with also with how to take care of those things in the city, how to make the best use of data about the events and the weather. And when and where and what do they think in social media. What can we expect from that to make a better understanding for the choices we have.

[S24] DM: Okay, thank you, you also say like you in the in the first part. You said you are more into the strategy, so I would ask you like in in doing in doing this, like, what… do you have some sort of like management tools that you're using. For example, different strategies different policies that are dating you as smart city initiative as in conduct, in using big data analytics?
[S25] BL: Ahh if we have any management tools.. Actually, we have a strategy in the city, not a strategy, rather than… it's much better to do things, try things and see what we can learn from them.

[S26] DM: Okay

[S27] BL: So, that's our strategy, not having a strategy, but that's a strategy. I don't know if I understand the management tools right.

[S28] VZ: There for example, it's more if you have some some, how you execute data management and governance at Helsingborg, at the organization.

[S29] BL: Yeah. Well, I would say two departments, working with data in the more professional way, if I may say so. One of them is the Department of geo data or geographical information which I used to be head of. We are about 10, 12 people working with data and data management to to collect data and and to see that data is used in in different ways. But also we have those working with… what's the word in English… You know, I dropped the word fell out of my head. It's called "beslutsdokument" in Swedish.

[S30] VZ: Okay

[S31] BL: It's a pretty used where we collect the information from all all kinds of systems like from the school or economics and everything and then we turn them into some useful data, in useful tools to the management of the city in all all levels so that they can see how how is the city working and what should we do, and so on. So we I think we have those two departments that are really good at this. But then also we have a digitalization department working with data more in how should we do with data in different ways.

[S32] VZ: Okay, so you perform all the data collection from different data sources so that you can have insightful information for the management of the city.

[S33] BL: Yeah, we do that

[S34] VZ: Okay yeah.

[S35] BL: From within the organization but also from from other organizations and other kinds of data.

[S36] VZ: Okay. In that case, when you're talking about the different organizations. How important do you think collaboration and data sharing between the Smart Cities systems and organizations for inter inter… interoperability

[S37] BL: Haha, yeah it's a hard word. I think sharing data is one of the main issues and one of the… if you want to be successful as a city or as a nation like Sweden, or like a continent like Europe, you need to share data in many different ways. And we are trying to share data within the city and I think we have down days for a long time and I think we're pretty successful doing that and also when talking about geodata specifically, we are already having those functions for sharing data with national authorities and so on, but also sharing data with the local businesses or anything. It's also vital and then of course a smart city is is good but smart cities is even better. So we need to share data between cities to understand more and to give also to improve the the common services they have because citizens doesn't just stay in one city, they are also in different cities during the day. So yes, sharing data is important and also we believe that open data is a good start, and we are working a lot with open data as well, but open data is not the only way but sharing data is more vital I think.

[S38] VZ: Okay okay and with this sharing, sharing perspective and the usage of open data, how do you think your external stakeholders and external organizations that works with you are ready, in terms of data access and cooperation?

[S39] BL: There is limited use at the moment. And I think that's a problem being, well known. We have open, I think a lot of data in this city, but the ones surrounding us and the ones that could make use of this data to provide services that we don't need to do them, they haven't found the data and they haven't really find a market yet, how to… yeah and be successful in using the data in different ways to provide services for which they could earn money on. so there are limited use but that's also a problem. We need to have more data from many different cities in a in a common way and common standard so that it's easier for for others sees the data.

[S40] VZ: So in that case would you we consider that the easy of use of the data that you provide them is one of the main issues or it's that they don't they don't know how to use that information?

[S41] BL: I think it's both, if they can find the data. I think it's not that hard for them to see how they can use it in in a technical way but then you need to see how the data could be matched up with other things to provide a new service or the service that the market wants. So first you need to find data and then you need to explore it and then you need to make the best use of it and exploit it since it's quite new in Sweden working with this kind of things. I think the businesses need to be more mature in in this so I don't know if they're, if it's the answer to your question.

[S42] VZ: Yes, perfect, perfect.

[S43] BL: So, so we're working on this we have hackathons to show what data we have or how it could be used to have a new new just for the week. So we have published a new open data platform that we hope is more easy to use and how to explore and see what data we have. So we try to do different things and this area.

[S44] VZ: Okay, great, great. So definitely, it will bring a lot of opportunities, the usage of open data and it's better if the people that are going to use them are, have better knowledge about how to use it, so it's good.

[S45] BL: Yeah,

[S46] DM: Okay, so I'll ask you again. What do you think, in your experience are the main challenges in in adoption of big data analytics specifically for enhancing resilience in smart cities, and if you could be kind enough to give a concrete example of your experience in that.
[S47] BL: Well, one thing is the quality of data. I don't know if I understand the question right but the experience of using data or the data is the quality, we need to know more about the quality of data we need to know more how to analyze the data, how to make the use of it. If we have any concrete examples I think I think it's about the quality of the data that is the problem.

[S48] VZ: In that case, when it comes to quality of data. Have you been involved in a specific project related with data quality where you struggled with some issues?

[S49] BL: You see, I don't work with those actions myself so I have kind of an overview. So I'm trying to think of a good example of, I wish I could make tell you more about not sure if I can do this. But in the case of business intelligence I know some and also in the case of using geographic data in other ways.

[S50] VZ: Yeah, that would be useful as well.

[S51] BL: So you need you need to find the data to see what it is and most, most of the times, the data is not understandable for anyone else than those working with the data because it's it's produced and maintain for a specific purpose, like in the utility management, they are providing data about source or water piping or so on but there are so specific that it's hard to use that data in in in some other areas because you can't understand it and those values that you are are looking for are attributes that you are looking for. It's not there because it's not in the interest of the the producer of the data. So often we need to talk about how to maintain and and produce more information, information that could be of use for someone else that's that's one one key thing we have been looking for and in seeing in using geographic data for instance, I don't know if you understand what I'm talking about haha.

[S52] VZ: Yeah.

[S53] BL: So yeah, so it's so, so it's it's not that often the case of technology it's I think we have the tools for working with data and big, big data as well, I guess. And we're working a lot with the ETL software like extract transform and load software. So we have been doing that for a long time
.
[S54] VZ: Okay, so in that case you, when it comes to technical uncertainties, there's not there's not a big deal there?

[S55] BL: There might be, but in… for where I'm standing and from where I am looking at this topic, I don't see the that should be a problem. But I think it's more, it's more organizational about producing and providing data for for for others to use and also there are some technical problems because sometimes you used to know the software or database that are not allowing others to extract data from it. So that's often the case as well in a city like this. I think we had the law around 700 - 1000 different software for different use, just in the municipality and and they are, there are a lot of them that are pretty old and the data is locked in some kind of big

black box. If you know if you understand what I'm saying,but so that's that's that could be a technical problem, but I think it's more we haven't demanded the right things from the provider of the software or database and also sometimes they want to earn money or or sell, resell the data in some ways, and I don't think that's a good way how to work in a smart city or if we want to use the data from for example we have a solution provider that are... we have this building permits system that aid us in the way how to to work with the tasks in these processes, but we can't use the data from that software in any in any other department or in any other use without paying them more money. Yeah, that's the reality they want they want to... because it's a… yeah… when when you bought it. You didn't have the right demands I guess.

[S56] VZ: Okay, okay. In that term, so you were saying that you have been doing a very good job when it comes to the use of big data on the city so..

[S57] BL: In some areas and then you have this definition is it big data or rather think we can say that that it is big data.

[S58] VZ: So when it comes for both terms big data analytics and if you have if you would have to measure how ready was the organization to adopt this technology. What would you say? For example in training in resources in culture and infrastructure.

[S59] BL: That is difficult because we are such a big city, but in, as I mentioned, we have a lot of different services and solutions in the city, but those building the platform in some kind of ways I think they are really fit for for the use of big data because it is… that's the evolution of those kind of platforms and has been, but then the organization yeah, there are people knowing how to use it and we are using it, but it could be more spread the knowledge and of course the knowledge, what it could mean to us, analyzing, big data. I think that's something we need to work more with. So if we feel the need to scale it from zero to 10 I think we should somewhere in the middle I think.

[S60] VZ: Okay, okay

[S61] BL: So it's a five.

[S62] VZ: Okay. It's a good it's a good start.

[S63] BL: I think so, I like to think so, but then I can't compare with others because I don't think we we talked about this with others... That much that we can compare in a good way.

[S64] VZ: Yeah, definitely, definitely

[S65] DM: Okay, to add to that. Could you tell us maybe about the top management support for the initiatives of adopting data analytics, particularly to Smart City resilience projects and yes so we're trying to see how the organizational readiness in that aspect. So how is the top management supporting these initiatives?

[S66] BL: I think we have a we have a good readiness if we're talking about organization because we have been working for you can say some kind of brainwash. But from starting from

about eight years ago, the top management have been selling us or they've been talking about this common vision we have in the city and we've been working with this on all kinds of levels. So I think we have the right mindset and we are talking a lot about how to do things we tried to do the right things, not just talking about them. We tried to do it so that we can learn and explore and also sometimes we can fail and from that start all over again and doing things better, and also the knowledge of data is better now than it used to be, because we've been working a lot with platform thinking and sharing of data. So that's kind of natural if someone asked for data they they share it, and then also talking about quality of data we're not perfect there but we are aware that there are different kinds of quality of data and we need to understand it more in the use of data and also think that data is one of the main pillars of smart cities. So we have been working a lot with with the topic of data in many different ways. And also we have this from the top management and the politics that that we should open up our data that that's one of the topics they they say to us that we we should open up more data, we should provide data so that others can provide services better than we are as a municipality, because if we look at all the challenges we have as the safety, we can't we can't we can't do them all, we need others to take part in providing services or doing things so open up data and services is a key issue to successful or to survive, in some ways.

[S67] VZ: Definitely, and here and now that you're saying that eight years ago is when you started to have the support of the top management. How important do you think it was for you, having their support?

[S68] BL: I think it's a… I don't know is the word is right but "vital", because if you don't have the top management. There are so many questions that get stuck in all kinds of levels. If you want to do something, then it's stuck in... in the right, in the wrong level because they don't understand and so on. So if it's a top priority from the top management, then you have a better ways how to do the right things that you think we should do as a city. So I think it's vital for for the success because one, one of the key things about this vision is in the mindset is you should do the right things. If you want something, do it, rather than who should do it, maybe someone else should do it or so. So from the top management we have this mindset that I can say that this needs to be done, then I do it. So that's how we have been working also with big data but other things as well in the Smart City to be able to do right things, not having the blessing for us from different levels.

[S69] DM: Okay, in in in your last description. You said that you you it's important for you to open up data, so I am asking the other aspects which are related to opening up data and managing data. For example, privacy of the data that is collected and also security. So how is your organization working in trying to to deal with to deal with those challenges or for example security, privacy user data, for example, that is collected in these cities. Could you tell us more about that?

[S70] BL: Yeah, of course, we have a lot of data that shouldn't be in used outside the city because we don't always have the right to do things that we should or want to do because you need the acceptance or the okay from the from the citizen in different ways like sharing data from Social Security, with the schools and so on. You need you need to have this okay from the citizen to be able to do that. So we are working with following the rules and the regulations in this area. And of course, working with the technical ways to this so that others can't intrude our

service or databases collect the data. So, so we need to be careful, but also it shouldn't be too careful because sometimes this is… it's used in some areas of this city for sure in other cities as a raised to not to do anything because you can say it's the regulations, it's too tough for us. So we need to do things to know more, but we know we need to do it carefully and we need to learn. But we can't say that the regulations or security should block us from doing those things we need to do it anyway. But we need to be careful and also have this also I think it's more mindset of knowing more about data and the risks of data and in the correct integrity questions around data. It can't be a few people in the city talking about this, you need to have this
Agree and please table desk. I guess over our desk. Do you understand? Also to your question.
[S71] DM: Yes, it is. It is. Yeah.

[S72] BL: And also I'd like to say that we are working with a lot of solution providers. Yeah, you know, maybe Microsoft or or those we need to rely that they are working on these things as well because we can't keep in touch with all the different threats and everything in the technical way. So we need to have others working for us doing these things as well.

[S73] DM: So I think this is pretty much what we wanted to learn from you. Is there anything that you'd like to add?

[S74] BL: No, I think it's no no not for now. I think it's interesting questions and I think data is one of the main pillars of a smart city or if even if you don't want to be smart it's still a main pillar, which you need to think about and I can comment that in one way is that in the city of Helsingborg we have 10,000 employees, but for a very long time they didn't tell anyone, not a single role not single employee working with data as its main priority and that's kind of weird I think, because we as a city have been working on a system level we're talking about systems and software, but not talking about data, and I think we need, we are doing it in the other way around. With the information and so on. But it's the data, it's the value that still stands. When the software is changed or their employees are leaving or change, data is the thing that remains in the city and it's the core value that we need to protect and take care.

[S75] VZ: Okay. Yeah. Okay. Sounds great. Sounds great. I think from our part, it's all that we wanted to ask you. It was great. I think we were 10 minutes of more than what it was scheduled, but you said that it was going to be alright if we take some time.

[S76] BL: Yeah, of course, and if you have any other questions, please email or schedule a new meeting. If there's something you want to add or ask or...

[S77] VZ: Okay, that's perfect. Thank you very much.

[S78] DM: Thank you. Have a great day.

[S79] VZ: Yeah, the same to you good luck

[S80] BL: Have a good day and let's keep in touch, thank you. Bye bye.

Appendix C- Interview with Jenny Åström

Organization (smart city): Malmö
Place and date: Malmö, 04 May 2018
Duration: 30 minutes
Type of interview (phone, skype call with video, in person): In person
Name of the interviewee: Jenny Åström
Job title of the interviewee: Program Manager for sustainable smart cities (Malmö) **Name of the interviewer**: Victor Zanabria

VZ = Victor Zanabria, **JÅ**= Jenny Åström
Interview 3

[S1] VZ: Okay, so first of all, some introduction questions if you can say a bit of your experience background

[S2] JA: My own personal?

[S3] VZ: Yes, your own experience background

[S4] JA: my own experience, I can, I've been working here for one year, more than one year, one year four months, five months and before that I am I'm in my former life I just to work with sustainable development as well. But with technical infrastructure systems, more, more. I've been a lot working a lot within waste management from many different perspectives. You can stay within waste for many years, I've been having different roles as a consultant and in a metronome Association, etc. and particular energy related questions from from energy from waste different ways. With innovation and other things, but also generally waste management waste policy and what everything connected with waste management and resource management and material management from so from that I've been taking two directions. One is when I was working with an export of knowledge and technology within waste management to other countries for some years. I've also been working on the area of circular economy.

[S5] VZ: Okay

[S6] JA: Going from waste to circulate it's quite natural because people think that waste management recycling is circular economy and that's not the same thing, the recycling is a fake circular economy. So, so I and I can see that coming from that side. So, because you have to work so much more upstream, of course it can be a part of the circular economy also in the waste management. But if you don't work in the whole chain, it's not it's not a circular economy. I have been taking those two directions and now I'm here leading these sustainable city projects. It's very different to work with sustainable development from inside of the city because it's not so much technical questions anymore. It's much more about organization and as the city being prepared to the transformation that you need to do now, with all the global challenges happening and how the city it is working and co working together and social sustainability and it's much more depth than the technical sustainability and I think sometimes we tend to forget the green

and technical sustainability and all these questions because they it's so much more into social sustainability and that's that's good of course that's to add them, they kind of forget we still have to improve on climate change, because otherwise we only postpone the problems.

[S7] VZ: That's right.

[S8] JA: Few weeks ago maybe you read there would be 145 million refugees from climate change in 2050. If you don't do anything about the climate change. So I mean you have to work on on solving the problem as well. Yeah, right. And so I think that's that's something I see that maybe the city is not, can't probably see, some people do, but it's not very clear.

[S9] VZ: that's also one of our main topics, the resilience of the smart city when it comes to different kind of external variables. One of them is mobility, but there can be so many. So, when it comes to big data analytics, how familiar are you with that topic.

[S10] JA: Big Data I know what it is but I do not work with it.

[S11] VZ: Okay. Okay. And when it comes to analytics and the analysis for planning of the information you have around the city.

[S12] JA: Yeah, I don't work with that I am more on the planning projects. That's another part of the city.

[S13] VZ: Okay. And when it comes to smart resilience how familiar you are with it?

[S14] JA: With it, if I work with it?

[S15] VZ: In general?

[S16] JA: yeah, yeah, that's, I would say that's that's our, the purpose of this project, to create a more resilient and sustainable city.

[S17] VZ: okay, okay

[S18] JA: Smart yes or no I mean for me smart cities are resilient cities so I don't connect smart. Today when you use smart you connect it to IT. But that's I think that's something to discuss because why why is that smart city. If it's not based on creating a resilient and sustainable city. It's a tool, IT, it's not it doesn't... You can have IT and internet of things and millions of things but if they don't push you towards an improvement. It's not a smart thing so for me a smart city is not equal to digital city, it's probably a tool that you need to go there, but you should look at it as a tool and not as the solution.

[S19] VZ: Okay. Okay. And so in that case you are mentioning that you have been working with waste management energy and so on. And.. which of these components is the city of Malmo working with? Which of these components such as energy, waste management is the city of Malmo working with now.

[S20] JA: Well the city of Malmo has to take care. We have the responsibility for all the waste management, So, you have to work with it. It's by law. I mean, we have so many municipal, municipal responsibility for waste management.

[S21] VZ: Yeah, but besides waste management, you work also with energy mobility housing.

[S22] JA: Oh, you mean okay okay yeah you mean develop those things. Yeah, everything

[S23] VZ: Everything, okay okay

[S24] JA: You can find some people that works with everything, everywhere.

[S25] VZ: Okay, you were mentioning as well that the technologies, new technologies are more a tool than an end. Yeah. And what do you think it's the was the organizational incentive to adopt these new business intelligence tools, so that you can have a support from the technological part.

[S26] JA: We work with it in the project I am running. We are trying to define the needs and challenges challenges in the city development processes that is ongoing and defining them together with this particular needs stakeholders, challenge challenge owners can say that in english? Needs owner?

[S27] VZ: Product owner?

[S28] JA: Yeah, yeah, trying to define what is actually need and redefined the need so that you will look upon from a different view what is, you can see many there but they are really something else, if you want more stakeholders to create something together and then we look upon solution. And then I see might be one of the solutions and but then you have to work in a different way within the city because then it is not so clear who should run this process, who should work with in house or cooperation with other parties or that's kind of, the city needs to find ways on working outside of the normal structural… I'm not used to talk about this in English so often, so I worry I'm lacking vocabulary, because I don't, I don't speak much English these days. So I lack lack of words. But in an organization you have if you can organize in lines… what do you say, silos?

[S29] VZ: Yeah

[S30] JA: yeah, silos organizations if you're doing that you cannot work on in a way that we are trying to encourage that, because you have to be more open minded, you have to have roles that are more free and so connected to silos, going between them and and that's what we're trying to explore now using different new roles in in the city and see what they can create together with other stakeholders in the area.

[S31] VZ: Yes. Okay, okay. And when when you're mentioning that the idea of it's to break this kind of silos, so that you are more connected, because we have different kind of information sources. When it comes to waste management energy that might be useful for not just one department but for many departments in the municipality and how you feel that the municipality

is working with that, with this idea of being more collective, have access to different kind of information be more free when it comes to yeah get information from other departments, so that you can have better insights of what you need to do.

[S32] JA: I think the communicate quite badly between the departments, there are not that good structured for that. There are a lot of improvements to do. It works sometimes I would say at some personal level and some routines works, but it's not. It's more coincidence when it works. Nobody has really looked upon this, what I see upon it, as a process going through the different silos and how they should communicate with each other. It has been developing by itself, sometimes, but then it's not so resilient because there's nothing that we could if it has been developed by itself. This kind of good communication between the silos and exchange of that, it can also fail because it's very much depending on different persons. So according to me, they are, there are many, many things that are not clear where goes my responsibility when finish yours and things like that and who should deliver what to who in between the technical departments within the city of Malmo, it's not clear at all. you might find processes when it's clear but I would say we need to… Because all I've seen that within the different departments, they have been doing process mapping, but I have never seen the process mapping for the whole city

[S33] VZ: Is a bit more lack of integration then.

[S34] JA: Yeah.

[S35] VZ: Okay. Okay. And here for example, how do you consider that the top management support this initiative for adopting new technologies that allows you to be more integrative, more cooperative?

[S36] JA: If you don't know that you should use those technologies, you, you, you have to start to be aware that you should be more communicate and want to do it and then you can adapt technologies, but I mean, you don't start with the technology. I think there's not, there's nobody that... there's not a demand for it. You're talking about within the city?

[S37] VZ: Yeah, within the city department, the top management.

[S38] JA: There is not a top management, it is a political organization, and each department is run by its own board.

[S39] VZ: And there's not a board at the top of all the departments?

[S40] JA: No, the city runs like that. it's a it's a democratic process that we have. each department, it's not department. It's a "…" in Swedish, environmental department... Yeah, it's a department. Yes. Okay. City city billing department Romans. Yeah, it's the department. Each department has its own own political board,

[S41] VZ: And there's, how's the communication then between these departments?

[S42] JA: In the non political level?

[S43] VZ: In the political level, or the ones who are checking… Okay these departments, of course they work independently, but that there should be somehow communication and so on.

[S44] JA: Yeah, yeah. That's what I was talking about earlier that yeah. There is, of course, but it's not it's not fully work through. I've never seen that process mapping for how to work between the different departments. It's working in some ways, in other ways it's not working. And so it's very much depending on different initiatives. Okay. Of course they're the city has as City Council of course they also have one… but then you can read, you can read about how a city Swedish city works, it's maybe, it's better use your time reading about Swedish municipal organization, how it works. This might be different, there's no management in the city.. Okay there is management, but top management is there is not because, and I that's that's a little bit frustrating when you work in a the city because you don't have these managing directors that are directing everything.

[S45] VZ: That's right. That's right. There's a bit of lack of that.

[S46] JA: Yeah. And then, municipalities in Sweden compared to other European countries and other countries in the world has much more power and much more independency compared to the state and the national level than in many other countries. You should know that as well because we're not so much.. the city level, the municipal level is stronger here than in other countries. It's much more that is left to the cities to do. So that's why we're so depending now for meeting up with the challenges. Because national regulations and directions are more general and is up to the cities, how to adapt them, and how to implement them.

[S47] VZ: interesting. I think it's a bit more, somehow better when you have to take some decisions and not depend so much on the others

[S48] JA: Yeah, because that's the idea which because of them becomes local adapted, but then if the city has to be organized in a way that it can meet up with new challenges and that's that's the problem. I would say in all the Swedish cities now.

[S49] VZ: Yeah, that's right, that's right. Okay, and when it comes to the information that you manage information let's say in your department. Do you think there's a data governance over that information. Someone who defines the roles, the security of information, who, who are the ones who have to have access to some information or not?

[S50] JA: I work in a strategical department. We don't have any kind of we only run projects development projects, if you talk to me I don't I don't have a role in the in the line and normal daily operation. I am not a part of that. I thought you knew that I'm running an innovation project. Yeah, yeah. So it's not like I have a day the role that we we have people here in the house that works with and for example, have a have an authority role because they they have a control on systems and operations and environmental control. They work, they work in the in the daily operation of the city. But I'm not a part of that work.

[S51] VZ: Okay, okay

[S52] JA: Supervision of businesses, authority, mission

[S53] VZ: Okay. So then, so I would like to know a bit about the cooperation between the Smart City systems. We were talking. So you're saying that there's a lack of integration between these departments and in order to achieve this is smart city resilience, how important you consider this corporation should be when it comes to you said that there's a lack of process that integrates all this city departments. So you consider, from one to ten. How much will you consider collaboration will be?

[S54] JA: I think it's ten, and the what I said the counseling that you tried to contact, the sustainability office is open after half year ago. Maybe it was one year ago with one person and now they three persons or something but it's not a project, they are they are permanent there and they they are trying to integrate sustainability within the operations and they have started to work with the budget process to integrate sustainability in that. So that's one of the ways that they have started to to implement it from from the inside to connect the budget. The city's budget process to sustainability and the development goals. So, they have this thinking about implementing it from the inside and then it comes when you start to without thinking, then it's communication and exchange of that they're not come naturally after that. So they have mission now, to, to, to work with this. But they recently started it and I think you should talk to them. Yeah, if can wait those eight weeks

[S55] VZ: unfortunately, is not possible, but okay... Okay, when you're talking about the strategic management projects. When you do the planning of these projects. How do you manage the external stakeholders. How do you consider them important for achieving this smart city resilience? I mean organizations outside the municipal?

[S56] JA: Yeah, it's very important. That's why in the project I am running, the innovation project we are trying to to integrate external actors within more into the city by by exposing the needs and we are trying to define the needs that we find in the city development process together with stakeholders, local stakeholders and and we're trying to match make them more external parties and that could be anything, not only technical, technical solutions, it could be any kind of solutions. So it's very important that we we work with other other parties and also one of the work with them and see the development process in a geographical area, we're trying to see how we can instead of pushing out the value that is already there, but businesses culture, whatever we're trying to see how we can roll on that instead. For example in Lund now we're working on together with the property owners and other stakeholders in the area trying to do to develop a common development development fund, not a fund, it was a fund in the beginning. But now, now we are looking upon that it should be more like a company sort of development business together and house, but where we work together in develop the area, the stakeholders and real estate, property owners and local businesses and municipality. So we're trying to create that now. So instead of the city, we can push everything out and start from the beginning of trying to work with, who is already there.

[S57] VZ: Yeah, that's right. So how is this communication flows between you and the sixth journalist stakeholders. How do you share it in the information between you and..?

[S58] JA: when it comes to exposing the needs and now we're working with external stakeholders to define the needs, but when it comes to exposing them you're looking now upon a tool a matchmaking tool, to to to expose the strategies and needs that we have defined. And of course you will have to have personal meetings, of course, but it's a way, it's a database where we can expose the needs some challenges so we can get in new new kind of innovators into the city, but maybe have a solution for them not only work with a master we have that our biggest ones have access to information is like that. So that's a part of my project to try to design this, develop this matchmaking tool. We are on the starting point to that. The problem is that we don't have enough needs yet we're working on defining the needs and they are not really, you don't have, they're not really ready yet. So we have severe but we're trying to develop the same time so. **[S59] VZ:** okay I'm here for example when you were explaining that there are not specific needs, do you consider there as well.

[S60] JA: There are need, but you're trying to define them and find them, there are many needs

[S61] VZ: Okay, and how difficult is to attract these external stakeholders to be involved in your projects? So, for instance, if I am a startup or a company that would like to develop a solution that helps the municipality, they might be thinking that there's not too much market or not it's not too much profitable business. How do you consider that?

[S62] JA: Yeah, that's what we're trying to work with, we have to look upon how they can get an interest in investing in the area. For example, by looking among social innovations combined with the technical innovation value relations. What kind of values are created by the innovation and who who what kind of business models should they have and what can the city, what parts of the city have in this. For example, if they invest in in an area where they also create social benefits that would be good for the city in a long term perspective. The city can be part of the work, working proactive by being a part of supporting this action but then you have to have value calculation. So that's what we are working a lot with that to trying to to find ways of getting external partners interested in investing in the development areas.

[S63] VZ: Okay, and in terms of the organization, the department that you're working for and the municipality as well how ready, do you think is the organization to start working with these new innovations that will be developed by these external stakeholders.

[S64] JA: So that's the challenge and our project that we have. It's not so easy because we cannot only work with that we have to work with the organization because the organization is not ready. That's a basic problem. When you work differently on developing the area and you have an old structure like we used to have, how should you do that, who should take what decisions, who should do what so that's what we were talking about in the beginning it's it's part of the challenge to to to to make the city, more, more ready for this.

[S65] VZ: Okay. What do you consider the most important or the most critical challenges that you have for achieving readiness for the organization?

[S66] JA: The lack of management and common goals and the way the city works today, we have to think differently.

[S67] VZ: Okay. And when it comes about the policies. Does the policy support you for attracting or for adopting new innovations?

[S68] JA: Yeah, they are policies yes of course legislations and things that shelves the directions but they're more like a technical level and a kind of. So it's not that if you want to adapt them in a good way and also implement them in areas where you have a social needs and things like that and you're working in, you have to… policy is not enough. It's not a solution. It's a help in many ways, but because you get much better investment calculations and things like that due to economical steering measures and things like that, but it doesn't.. It can be helped. But it doesn't really creates the solution, just support it

[S69] VZ: Okay. and so when it comes to these innovation characteristics that you were mentioning, What would it be the most important thing that you will focus at when deciding to adopt new innovation? What would what would be the most important factor or characteristic of when you decide to adopt a new innovation?

[S70] JA: Well, that's I don't know I can't really answer that question we are working on, this is a this is a big question. So we haven't really got that far. I mean, it's a big, the most important factor is… well you can adopt an innovation, but is it the right innovation that's what we are trying to work with. Is it the innovation that will create the solutions that we need? That will push us forward to create this social society, work with the climate change and everything? So definitely the problem is not adopting it. The problem is finding the right the right innovation working with the right stakeholders and then adopting it, then it's again the organization because we have the silos. So who should take that decision, so we have to work on those two levels all the time, and this, the project I am running, we are testing, it's not nothing in [not understandable], but we are actually working in actual physical area. So, we will learn from that and we extract what we learned from that now we have been running fully with more than one year. So we start to get quite a lot of proves that we now we plan to show for the city that okay we have seen that and that and that, what can we do about this. So, and who can take care about this and what changes can we do and so it's not the, I'm not in a position I can do initiations but I can propose from the results from the project that we have seen. So, yeah we're working on different levels, it's quite complex.

[S71] VZ: Yes I can understand, just for finishing the interview, I would like to ask if you would like to add something else that you considered important for the topic that we have been talking about.

[S72] JA: No, it's just it's just so much more complex than you think. We're not the company, we are a city and that makes thing really different.

[S73] VZ: thank you very much, it was very interesting to hear all this kind of things that you're working with.

Appendix D- Interview with Peter Kisch

Organization (smart city): Lund
Place and date: Lund, 18 May 2018
Duration: 44 minutes
Type of interview (phone, skype call with video, in person): In person
Name of the interviewee: Peter Kisch
Job title of the interviewee: Project Manager (Future by Lund)
Name of the interviewer: Dianah Mlokozi Victor Zanabria

DM = Dianah Mlokozi **PK** = Peter Kisch **VZ** = Victor Zanabria

[S1] DM: The first one, we want to know a little bit about your background and experience

[S2] PK: So, you want to know what my background is

[S3] DM: Yes and experience.

[S4] PK: As a background, I am a chemical engineer, I have been working with process management, that's my background. All kinds of automation of chemical processes but that's way back, then I get into product design specifically to waste, waste management systems, water, energy, basically cleaning technologies, you could say, or the environmental technologies. The design of those things and then I sort of slowly merge or moved into Smart City.

[S5] VZ: Interesting change from chemical engineer to Smart City.

[S6] PK: Is not so big difference. I have a lot of advantages, I mean a lot of the technologies that are that you use in the industry in chemical industries are used in cities. Basically all the… especially when we talk about water and sort of based on. Also flows and flows and analytics is very useful for when we are talking about mobility flows for instance, I can use a lot of my previous experience.

[S7] VZ: Okay, great.

[S8] DM: Then, we would like to know your familiarity with smart city resilience and big data analytics technology and maybe perhaps how you perceive big data analytics in achieving smart city resilience?

[S9] PK: I think that there are… My personal opinion is that there's, there are two things two ways you can look at it is one could look at big data analytics or smart cities as a control of the city It's like you have, let's say the airport, you have a tower that is sort of guiding all the flows of airplanes and the traffic. So that's sort of a control room thinking, you know where you have some guys that are actually managing the city in using advanced computational capacity or skills to to make decisions or even predict what will happen in traffic or whatever. So that's one

sort of way of thinking, the other way of thinking is that big data could create a smarter city in a collective intelligence within the city and within layers. That means that today we are.. how to say it, let's say if you take the bus system in in Lund. So we have Lund municipality okay, so we have the roads, the people and we have also local policy that's what the municipality is doing, then we have the region of Skåne, now they are sort of responsible for public transportation and that means trains, buses. So they actually plan all the routes for the cities, okay and then you have the operators, we run buses. And this is just the public, the local public transportation system. So we have three, and if we then add taxi, national trains, national buses, in all these, you will have additional organizations. Now, the only way to create sort of intelligent system around this, where they understand, okay, from a consumer perspective or citizen perspective What's the best design of the system? Because now everybody is optimizing their own business. That means that they're cutting out their niche market in the city which creates a lot of crazy solutions here and now and this is just people management. We're not even talking about logistics. And the only way to, because they, these guys cannot go into the other, because they are totally different organizations. The only way you can make these organizations work together smarter is that you create some kind of a common base of understanding what's what's, what's the situation like. And that can only be achieved by three dimensions as I see it. This is why I think the is is really interesting with with big data, that you can actually see your your part of the pie. Okay, this is my responsibility or my opportunity and this is the way I can into play with, it can be a competitor, but it can also be your collaborator, it doesn't matter. But, so it's, it could be a way to create something that is much more suited for for for citizens. So I think that you need to be careful when you're talking about smart city because it very much depends on what's the basic social structure of the society. Okay. If you talked about a country like like China, most likely, this will be much more easy to do because we will just dictate to everybody: “this is the way we're going to do”, it doesn't work in our society. So it's very much based on what sort of, what is the political sort of structure background. What do people think about things. So I think that there are two streams here. One is this sort of top down control management thinking like I would, if I would be a process manager in the chemical plant, I would have a control room to control all the flows and I will know exactly the temperature of not cancels tweak it a bit by one 1.5% I could increase the production rate, so that's one way of thinking. The other way of thinking is is this okay by just providing really then intelligent information the whole system would based on information work much smarter than without putting the common information.

[S10] VZ: So, you would see each of these different stakeholders as data sources for you to integrate all that information and it started getting knowledge and analyse..?

[S11] PK: yes, yes and today we're not there because this is as it is now. Many of these players regard their own information as as as a resource that they don't want to share. So it's a trust thing, also I think it's basically I think is the same situation as we had when you when you started with paper money. I mean, you know, does this money actually exists. I mean, basically just a matter of trust that this $5 bill actually is worth $5. I think it's the same thing here, it's a it's a matter of basic trust. If I gave the information will I get something back?

[S12] VZ: Yeah

[S13] PK: And you know, we're not there yet. I can see that the trust is not really…

[S14] VZ: Is not there yet

[S15] PK: Is not there yet.

[S16] VZ: Okay

[S17] DM: So which exactly Smart City components are you working on right now like is it energy, is it waste management?

[S18] PK: Well, we are doing, doing on energy we're doing some projects, basically we are doing quite a lot on sensor, sensors technology and on trans, mobility, those are the main ones. And the way we do it is in small, small, manageable matches or experimental pilot cases, because if we we want. If we go big too fast, that means that it's difficult to manage. And also it's also a matter of transition, transition capability of the organization. We lack basically in the public sector the the knowledge on on various simple issues in digitalization, it is very low. So the competence level is too low to to take that transition steps as it is now. We need to build knowledge and competency in order to make that step. So, we are lacking, we are lacking competence. Because I mean, this is well known to you, but it's not to them, but if you want to make this sort of step towards big data analytics, AI, whatever you want to introduce in the organization, then it's not about hardware and service, and you're still in mindset, they are still there:
"are we talking about the computer or..? No no, we are talking about total different way of organizing how it should be operating" and this is very scary for them: "What happens to me? My job?" you know this question start pumping up. So I think that in this transition phase is very difficult to manage. Because we can demonstrate pilots and experiments. So this is the way should function, okay, now we want scale it up and then it has a huge impact on on on the management and organization and this is I think this is the more difficult thing. Maybe we can discuss ideas or what we want to do or how we should do it, and even bring out really interesting, also even on an international level, interesting cases, but ok now we want to scale it up and that's where are really the big challenge is how do we get the organization on board. This will take more time to make the transition.

[S19] DM: So, in the aspect of organizational characteristic like how do you consider maybe the top management support in actually influencing the adoption of these technologies?

[S20] PK: Today I think the management is aware of that they should be taking the step. But they're not, you don't see it happening. You see it here and there, because if we can understand how it works.

[S21] VZ: Before you erase it can I take a picture of this?

[S22] PK: Okay, the way is organized is that you have some kind of a political level, and then you have a coordination, we call it the mayor' office but it's not really the mayor's of the central of coordinating all, and the you have all the departments, culture, environment, It's a very sort of old fashion organization of the municipality, and then on the side here you have the local energy company, the local waste water the local waste water, the parking company, the housing

company. These are all I think there's six or seven of them. These are individual companies but owned by the municipality. These are profit driven organizations, say, but not profit in the sense that they should maximize profit but profit driven, they are under, these are under the legislation of this Swedish… the laws governing the companies, you can say with the board and shares and etcetera. With the difference of a private company that since they're more than 50% owned by by public organizations, there are certain rules that apply to publicly own companies. So there are some things that they can't do, and the degree of freedom is is a bit limited but otherwise they're sort of basically equal to private companies. And then you have a lot of small and big private companies that are sort of suppliers or actually executing services for let's say the health, the health department. They're actually client of a small nurse, nurse based company. It's okay, take care of this specific service we want to provide for for our citizens, and also and then also we have schools, public schools and private schools. And then I will say in these companies here, here the maturity and the the... actually the interest in digitalization in a broader sense is very high, and they actually done a lot of good things. The local housing company is actually I would say market leading on automation of housing systems, ventilation, energy systems and all, they are really, really top. Also on on black fiber and the services for for. It's really good, but it's it's very much than we are here. But it's also because they're on the market, operating on the market, whereas the municipality is not. So it's a monopoly.

[S23] VZ: So, it's a bit difficult.

[S24] PK: It's a bit difficult to, and it's also because you should underestimate also that the public policies have another problem is that they should they should guarantee stability. They should see secure and neutrality. They should also secure that you can be able to store all information, for instance for 200 years. That means that all our plans or our building plans still must be printed on paper. There's no other way other storage, you know, digital storage technology can't guarantee 200 years of storage so everything is printed on paper and put in the [non understandable] still. So there are some practical problems why you have a sort of, a lot of roles that you should undertake Whereas I think that also, when you come from okay, why don't you just digitize everything is very simple. Yeah, that, that is easy, but all the other responsibilities may not be so easy, so that's why you have the slack or the drag of things slow. Because you need to find solutions for everything, not only sort of the easy things. So the companies, I think they have done a lot. On the top management here, everybody's is on a varying degree. It's also age related depending on how, what... what generation I will say the manager is. I mean the ones that very close to retirement it's like just wait two more years and let the other the guy do the things. So whereas I think the younger ones, they are more sort of ambitious, they can see that they're really into. So it's a bit varying but I think that and also in the organization, I think everybody understand that something needs to happen.

[S25] VZ: So each of these departments has their own top managers I would say?

[S26] PK: Yes

[S27] VZ: So is there any entity or board that talk to all of these managers in order for you to have an integral plan? Or each of them act independently?

[S28] PK: We have a very stupid setup we have something, we have on top of this layer here with you. I hope you wouldn't have gotten this question actually sort of political board for each. But they don't, I mean this management level here, the way we distribute money here is that coming for the political assembly. Not through this one here but directly to the different departments that that means that here we have some, in the assembly you would have fifty, and then you have a small board here which is the executing board, around ten. But then you have also for each department of political bord you can say. So it's a very… if you look at these on organizational point of view it's not really organization. It's more like a network. So so you see the politicians in the board here, is actually here. So here when they go down here they're representing the let's say the school but they're also representing their individual party and themselves. So it's in realities, it's a very sort of, I mean the old the old idea was to guarantee democratic influence, but in reality we got very inefficient management of the departments, because all these mixes of political wheels on, and it's, and I would say that the collaboration on this, on the horizontal level like this stuff you would like to see on the digitalization issues is very low, because as we have now you can't say okay let's say this department, this department, this department should work together. So these tasks, it would be cheaper, faster and smarter and they are simply unable to do this, not unable but very, very challenging task.

[S29] VZ: So the collaboration between departments is not, what what would you call that, the best or the one that you would like to have in order to have an integrated solution?

[S30] PK: No, I mean I think what is missing and what is for me actually pushing for that you need to have some kind of coordinating digitalization unit and I think it's coming this fall. But this is what's missing right now in order to push we push because some of the issues that we're discussing are general for all the department's. Not everything but a lot of things that are. Then also on top of this, we have today. So this is, if you look at Sweden like this. We have 200 I think some beyond 200 municipalities, 250 something like this, whereas the people, the concentration of people are basically like this. This in north of Stockholm is this little bit here and here but otherwise it's so pretty much empty space. And that means that that looking at these solutions only on an administrative point of view, only looking at this is, this is one municipality and this is another municipality and all of them should invent their own solutions. I mean, we are only 8 million people or more closer to 10. Yeah, 10 million people, which is a city in some countries.

[S31] VZ: Yes, my city.

[S32] DM: Also mine.

[S33] PK: So that's why i think that i think you should be careful to invent or create solutions only, I mean for this small town you need maybe to have a national strategy for that could sort of help cities. So there's something also on a on a national maybe a regional level that is, that is missing. Because you can't leave the cities to invent their own system, is simply going to be too expensive.

[S34] DM: So there's no like something as you said a national coordination body or strategy…

[S35] PK: There is, there is. But it's not in an effective sense, I mean it's it's like, it's national policy making, its national competence building. They're doing, forming alliances and networks and workshops, but it's not in effective terms in the sense that they're investing. So this is what I'm what I'm pointing out that you can't only talk, you need to do things also together.

[S36] VZ: So in that case, now we are about working together in different departments as well as between different smart cities and private companies. What would you say are the main challenges and opportunities that you find when working with these external and internal stakeholders in order for you to digitalize for adopt new solutions like big data analytics?

[S37] PK: I think you need to rephrase the question, I couldn't get what you..

[S38] DM: So he's basically asking about the opportunities and challenges of working with external and internal stakeholders in the whole process.

[S39] PK: Okay, okay, okay. To form the solutions do you mean?

[S40] VZ: Yeah

[S41] PK: I see it as as the only way forward because if you look at, I don't think that the tax base. I mean, if you go back 20, 30 years ago. Many of the solutions were developed and driven by public authorities in Sweden, also because there was a lot of money in that section. But if you look at the income from the tax, let's say income based, tax coming from incomes to to as a revenue to to the public sector is most likely going to change, the tax space is going to shrink. That means that we that we need to find collaborative schemes with other parties too, and that's one aspect of it, the financial…

[S42] VZ: One challenge would be the financial.

[S43] PK: Yeah, the other solution. I think is is I think that people is basically going to expect that you collaborate. They are not, is not they're not going to buy that the public authorities is going to develop something for you. They want to be engaged and I'm not, I am talking on individuals, as well as organizations. So I think there is, and then of course you could also think of maybe from a sort of democratic point of view, as I think in general terms that that maybe you could get the sort of more stable society or, if it's more inclusive in the solutions.

[S44] VZ: Yeah, that's right.

[S45] PK: So I think those are the driving forces. I mean, I mean, I think that if you want to go forward the digital is I mean the technical aspect. I mean, we get, we are getting hammered every day overwhelmed by technical solutions and what you can do with with new technology, we don't we don't lack opportunities. What we need to find is the match between the technical possibilities and really what's the need in the city, and that is basic very much. And what the companies, citizens and organizations really need not what we can do with the technology.

[S46] DM: So, what do you think are like the major weaknesses towards the adoption of these digitalization of big data analytics in achieving specifically smart city resilience?

[S47] PK: The drawbacks?

[S48] DM: Yes

[S49] PK: I think it's the obvious ones, like security is a big issue, of course. I think also maybe development control, because as you merge into these digital solutions you most likely will end up in the needs of one of the big companies, you know, Amazon, Google, as it as it is now. So you're going to be trapped. I think this is also people feel like oh shit, it's just this hell or this hell or that hell, I gotta choose. Because they feel that they're gonna be there, they're not gonna be able to to to influence. I think it's just they need to accept that this is what is on the market.

[S50] VZ: Yeah, that's right.

[S51] PK: So that's one one aspect of it. But then again, of course, I mean, if you want to develop something on your own is going to be very tough, so back and forward.., But that is, if you were just talking about drawbacks that sort of, the lock-in is always an issue. And then of course there is the personal integrity issue. I mean, that's a big issue. I also think there is something that is that people may think, I think there is a risk that the digitalization will sort of create seemingly simple solutions to things that require personal interaction. So by automating things and digitalizing, you create some, something that looks very smart and efficient immediately but the risk is that you take away sort of personal interaction, and still I think that personal interaction is always superior to to technically interaction.

[S52] VZ: okay and and now that you have been talking about the weaknesses. What do you consider the strengths, themain strengths?.

[S53] PK: I do believe, I mean if you do it in the right way. I really think that the issues like that… You could actually increase transparency would be one big thing you could make more I think there is an opportunity to make, make more inclusive, we can properly most likely get more smart design of the solutions. If you do it in the right way, I do think that we could deliver new type of qualities, and in fact if you do it the right way you could do things in such a way that, the things that do not need personal interaction, could be full sort of digitalized. and then you can put the effort really on the things that really need sort of personal information. So it's sort of a polarization of the services you can say, you can already see this happening now. But, for instance, if you're looking for what's now being a very cautious in process, the process to get a building permit. You can say that, well all the easy building permits, they can be handled by a n automated process which is should be very easy because I mean, it's basically just setting up sort of boundary conditions and then you get a yes or no, automatically basically. And then the real difficult issues, you could really sort of focus on more personal specialized interaction with the customer. So I think this is a really... and then of course I mean hopefully we can make more for for the taxpayers money than digitalization that's that's a very, very important issue. Because if you look at what it looks like the the expectation over what the municipality should be doing is going this way, whereas the the income from the.. from the taxpayers actually going like this, going on like this. So, this gap here is really the.. And this is... partly of this is going to be taken care by digitalization, hopefully.

[S54] VZ: Okay, I think we are basically done, so we wanted to ask you as well. If you have been, maybe not here here, Before been involved in big data analytics project with the municipality.

[S55] PK: We've been involved in small, basically pilots cases. So we do projects with most time with energy company or the automation like Schneider electrics these guys who do and the backgrounds, we have had some discussions with IBM and Microsoft. But that's true, that's true. The Schneider Electric Company. So we're not directly working with… because we don't have a city platform as such, we've be looking into sort of putting one in place, but we're not we're not there. So what we do is is in the individual either. That's why I'm trying to say that either in the housing company or the energy company. That's where they doing the big data and analytics and so on. But that's all as thematically isolated. So it's not really, if you're not sort of cross running energy with mobility, mobility. So is basically one at the time. This is the next step we're looking to do.

[S56] VZ: Okay, Okay. And if you would have to measure the readiness of their organization of the city as a whole you were saying that there are some problems trying to, that now you're creating a single digitalization unit. But if you would have to measure the readiness from 0 the 10 of the organization to adopt this new technologies what would be your personal.

[S57] PK: I think the mental readiness in terms of fear is probably eight, nine, the realization that you need to do something. But on a capacity level, the capacity readiness is below five, I would say maybe three. That's why again coming back to the point of focus. It's a, it's like you realize you. you know you smoke and you know that you shouldn't be smoking, but you need to stop smoking, you understand here that you need to do it, but you don't do it because it's a habit. And this is why I'm saying it's in, in, in our case it's it's I think it's it's actually competence and knowledge, and of course its resources also but it's basically how should we do it. There is too few people that know how to do it. The skills, yeah, so I think that, so you need to divide your answer to one is the realization that we need to do something, that's very high. Everyone knows that we need to do something about. But, in, in fact, in reality, the capacity to move is is much lower.

[S58] VZ: Okay. And in here as well. When it comes to data management. There are different data sources that you have here, different organizations, different companies. How important do you consider the aspect of data management here to make this city work as a whole?

[S59] PK: I mean, I think, again, I think that the data management is is you need to, you need to decide what you want to use the data for first. Coming back to the issue again. I mean, what's, what's your intention? Do you want to have some smart inclusive society, or we want to have a control room? or maybe a combination of both. And then you can decide of okay what setup do we need for this. Because collecting data just for the sake of collecting data has no value for anybody. It's, you know, you want to do something with it. That's fine, coming back to you as a as a process engineer, I'm collecting data to understand the quality of my output of the quality of the input or the the temperature of the specific process part or whatever that's and then I'm sort of taking a decision based on that. And this is, again, this comes back to what what do you want to achieve, what is it that you want to do with the information you collect. This is, I think that's the most important question because only then you can get access to resources. Okay, we

want to do this and then we will achieve this. Okay. And that will cost us so much in order to, okay then you can do it.But just say, we want to have open data platform to collect data and everybody was like “okay…what for?”

[S60] VZ: Yeah, that’s right

[S61] PK: Because it's a it's also it's a, I think it's it's a prioritization also what we're going to do with our money really, and or our organizational capacity was “should we do this instead of that? or combination of both?” So, so you need to put it into perspective and then probably most likely you need to break it down in very, sort of… I can see for instance in in our town and which is a town that is very small in size, but on the percentage of, I mean in city center, you would have maybe 100,000 people, but everyday 30,000 people commute or even more 35,000 people commute into, not every part of the city, but the north eastern part whether LTH and Ideon is neither alias some 30,000 people commute in every day. So I mean that's that's 30% of the city just going in and out, and it's a very small condensed space. And of course, compared to other cities in the world, the congestion is not that tough but potentially it could be very difficult so that that's where I see that sort of smart information systems could actually improve the traffic, because we end up usually in in infrastructure investments, you know, you make the road wider, or you can have another take off the road or you introduce a train line, but maybe the solution is better information. They are can actually see that they could have society use of having sort of sort of big data, sort of thinking around mobility.

[S62] VZ: Okay. In that case, you're talking about people commuting. How do you consider the importance of having a communication, not just with this smart city of Lund, but with other smart cities around?

[S63] PK: I mean, this was, I was saying before, that the the Regional Transportation, or the transportation system is run by, the public transportation is run by a region Skane. So I think that just as you're saying that no no I mean of course we can't only have some of Lund solution. We need to have it integrated with other things. So that's a that's a regional, regional sort of responsibility. But as it is now the region is very weak politically, because they're basically focusing on on on health care and the the railroad system and the buses and nothing else. So the political capabilities of doing anything outside...This is very low right now.

[S64] DM: So is there anything you'd like to add?

[S65] VZ: From our side there are no more questions.

[S66] PK: I think that we covered, I think that my general conclusion is just that there's not one solution that fits. You need really if you talk about the city, you know, this Lund is a very small city. So it's not sort of comparable to big cities around the world. But even if you talk about bigger cities, you need to understand really how what sort of, what is the essence of the city, what is the DNA of the city before you start talking about smart solutions. And then of course you can always find the small solutions for any sort of specific technical infrastructure. Like, like I was saying, like it can be,. I can think of running waste water management system as as a chemical process plant. That to understand that a mental mindset is there, but the difficult thing is when you start combining different kinds of information. How are you gonna do this...

[S67] VZ: The integration?

[S68] PK: Yeah, and I could I could assume that if you have a city where where the mayor is managing all this system and he's the top boss of everything and it's within the municipal organization, is going to be more easy to to create the common system. Here for us it's a big challenge and all these different you know one is private, one is public, this is semi public, so it's more challenging. So yeah, so the structure is very meaningful from a digitalization point of view. Always if you find the sort of top down structure that's going to be very much easy to implement, of course.

[S69] VZ: One last question is, it's fine for you to use your name for our project?.

[S70] PK: Sure

[S71] DM: Thank you.

Appendix E- Interview with Jonas Norrman

Organization (smart city): Gothenburg
Place and date: Malmö, 18 May 2018
Duration: 44 minutes
Type of interview (phone, skype call with video, in person): Skype call
Name of the interviewee: Jonas Norrman
Job title of the interviewee: Head of Innovation Services (Innovation Management and Communication Group)
Name of the interviewer: Dianah Mlokozi Victor Zanabria

DM = Dianah Mlokozi **JN** = Jonas Norrman **VZ** = Victor Zanabria

[S1] VZ: Great, then we will start.

[S2] DM: I'll ask you the first one, if you could give us an overview of your experience and background of yourself.

[S3] JN: Yeah, I have a degree, degree a doctor's degree in climatology from the University of Gothenburg and the last 20 years I've been working with climate mitigation technologies.

[S4] VZ: Okay.

[S5] JN: And I'd be working sort of from the technology side to start with and then I have been working with a your number of the university and I'm working with the research institutes in Sweden to different, the one called RISE, I'm not sure if you're familiar with the research institutes of Sweden RISE and the other one is called IBL, Swedish Research Institute for environment and since the last 10 year I've been partnering with IMCG Innovation Management And Communication Group where we more and more focus on implementation on new

technologies within smart cities. And my focus is more and more on the business modelling both for company's implementing new technologies, but also for those supplying or the innovators.

[S6] VZ: Okay.

[S7] JN: I'm assigned as the business model managers for one of 12 business model managers for the European Commission. So specifically I work for eight cities throughout Europe on business modelling for technologies within the city systems.

[S8] VZ: okay

[S9] JN: And I'm located here in Gothenburg, of course we work a lot with Gothenburg as well. But we also work with Helsingborg, that's why I know about Helsingborg and we are more in Lund as well and others. We just see this of course.

[S10] VZ: Okay, okay.

[S11] JN: So, so that's my background and my experience.

[S12] VZ: Okay, great. Perfect. So it's really, really interesting. And so since you have been telling us that you are working with different cities different technologies, would you describe yourself as very familiar with the data analytics with smart resilience?
[S13] JN: Eh, when I was a researcher, I did big data analytics myself climatology is pretty much all about that, you know, but since then I'm more inviting the possibilities on how to utilize that kind of systems and analytics. The big sort of challenge today, I think for many cities is not to gather information and do analytics. The big challenges are actually to upgrade their business processes to be more reactive to the result from analysis.

[S14] VZ: Okay,

[S15] JN: They, they. Most cities don't have very advanced systems, yet. But the ones that are thought to be more advanced, they gather information on for example for air quality monitoring in real time but still they just use this monitoring systems to do reports, annually or monthly instead of using the real time or even the short time forecast to implement control mechanisms for example, banned traffic. For example in some areas to using congestion chargers or anything so my role today is more to help to discuss is it possible to use modern technologies like big data analytics to, to come up with new ways not just monitor, but also to control the environment.

[S16] VZ: Okay.

[S17] JN: But then you're running through a number of new areas because it's one regulation and they can also be that the organization is not structured to do this and a lot of city is also worried about political risk. It is one thing to monitors particular when you start to control, like stop traffic during some times of the day due to air quality and people get upset and angry and politics don't like.

[S18] VZ: Yeah

[S19] JN: So, but I must say that from the resilient concept, that is not, I mean with in the smart city project I work, we don’t use smart city resilience. So please, I know about resilience but how would you like to describe the term smart city resilience.

[S20] DM: So, so basically we were trying to see that for example these cities have already implemented, they're using ICT to monitor to probe, to planning and to design solutions. But again, what happens when the city has encountered some sort of disasters or the certain threats or that have been happening in the city. So we're trying to see how these cities can actually use that is already available in smart cities in order to be able to maintain the existing situation or to even at some point maybe in crisis, how to manage crisis sort of that. That is why we are describing smart cities resilience.

[S21] VZ: So this is a new concept that you are researching out. How it can be implemented.

[S22] VZ: Yes. So in this case the would be, since you have been working with both how, how do you perceive this concept of the capabilities of big data analytics for achieving resilience smart city, the smart city which is flexible, which is persistent, adaptable with a lot of learning capacity.

[S23] JN: Yeah, yeah, yeah, yeah. Was that a question?

[S24] VZ: So how would you perceive which are for you. In general, the capabilities of big data analytics for achieving this purposes. **[S25] JN:** Within cities which I know about

[S26] VZ: yeah, yeah, yeah
[S27] JN: I would say that most cities have low capability. This is something new for many of the cities and they are not monitoring the systems in this way. I mean they do monitor utility, of course, energy, water and waste. But that is more of a process monitoring and presenting the basic strategy discussions throughout the city. If you understand my difference.

[S28] VZ: Yes, we do understand. Okay.

[S29] JN: And I think it would, there are a lot of things that could be monitor and be presented were quite easily nowadays with new technologies. But as I told you previously. Some of the skill. I think, I think you need to have some sort of political vision about why you would like to monitor the city and present some sort of targets for resilience, for example, and to set strategy to reach those targets and also monitoring up the progress, that kind of monitoring is I think it's a few politicians that would like to see that

[S30] VZ: ok ok so in that case, for example, in your organization. Could you describe what particular Smart City components are you working on are you maybe on the energy, housing or mobility or you're doing both of them.

[S31] JN: Yeah, I work with when it comes to energy. I work mainly with the district heating and cooling heating and cooling and electricity. And today with electricity it interacts not just with housing, but also with mobility of course charging is this an important investment in many cities right now.

[S32] VZ: Okay

[S33] JN: So we're charging pays as such but also when it comes electricity local production or electricity from solar cells or mainly solar cells and short term storage in battery solutions within both cars and houses is an innovation which is discussed and present that have demonstrated in many cities right now.

[S34] VZ: okay,

[S35] JN: in distributed heating is a tool also for Energy Efficient yes you can share heat between building if you cool one building, you can use that excess heat to heat another building and you can cool a building and produce hot water instead so when it comes to energy and mobility, housing. They pretty much start to interact. This is the big difference I would say in the last, 10 years ago you had the end consumption, either in houses or in cars or from the energy system was just distributing energy to the sources or this demand. But today you have to see more and more that you can interact, you can boldly produce energy into the grid and you can consume an injured from the grid and with that comes new business models. So that is what I'm working pretty much right now.

[S36] DM: In that sense could you say you're using somehow data analytics in order to remain those components

[S37] JN: Can you can you say that again?

[S38] DM: In that sense, the components that you mentioned are you in some way using big data analytics, or that analytics to implement those solutions that you have just mentioned.

[S39] JN: Unfortunately not. There are not such data available in the project I have.

[S40] VZ: okay
[S41] JN: Because we would like of course to have a great data set that would be on energy or mobility or so that you're good, but I as I said it is pretty much still on a basic level. So it is not yet utilized, big data analytics.

[S42] VZ: Okay, and these cities that you're working then, What do you perceive is their motivation for them to adopt new technologies and new solutions but if there is one case with big data analytics will be cool. But in general, what can you say they look at?

[S43] JN: In the Europeans cities, what they prioritize when it comes to big data analytics and the possibility to do it analyzes, it is not an environmental type, it is just on security so, so monitoring of potential terrorist attacks is super important for them. That's all the top for many of the cities that's where they put the first investment

[S44] VZ: okay

[S45] JN: On and also implement artificial intelligence, to monitor with microphones and surveillance on stress behavior from video footage set and speeding cars and stuff like that. Speeding trucks is a really an issue in most cities, a lot of cities have had terrorist attacks maybe you know trucks, to monitoring heavy transportation. It is typically a big data stuff.

[S46] VZ: Okay, great.

[S47] JN: So, I don't know in environmental side of course they do have their air quality monitoring, but I would say that it's still quite traditional you're monitoring, measurements at dedicated sites and you collected data within the last 20 years and you analyze it, like monthly or yearly you don't really sort of use the new technologies. We have a number of project that I would like to applause or complement compliment Internet of Things you know, sensors, distributed, chip sensors distributed much more to be able to have a big got a network of sensors. But that is in the very beginning, I would say.

[S48] VZ: okay

[S49] JN: and, and they don't know about yet how to act on that. It will still be just a monitoring not the controlling system. For me, the thing with big data would be that you actually can use the information to sort off control your processes

[S50] VZ: ok so in general they are in the first stage of the process of analysis which would be more descriptive more than predictive or even prescriptive.

[S51] JN: yeah yeah

[S52] VZ: okay, okay and you have been working with different cities and probably you have been in touch with the people from different positions and so according to your perception of in order for you to have successful implementation of new technologies and if you of course have case of big data analytics, how important. Did you can see there is the top management support on these new initiatives for the cities?

[S53] JN: I think it's very important. And I would like to include the politicians as the decision makers in the top management as well, that it is important that they understand the need of investment and the volume of investment necessary to have a good data, but also from that investment to understand the value of the new solutions not just more advanced monitoring systems. That they need to understand capabilities of big data systems for the city. I think they take it step by step you know, the investment in cities is competing with schools, health care, traffic and the maintenance of street, there is a number of different posts and it is tricky for a politician to change priorities and introducing the concept of investing in a big data then you will need to cut costs somewhere else.

[S54] VZ: Okay. And following with this topic about the organization, what would you consider as the main aspect when it comes to organizational readiness for adopting these new technologies

[S55] JN: What we see in cities is that they actually do reorganization. They realize that the traditional way to organize, the local authorities have to be changed to be to both implement the more digital way to work together, but also they will be different business process based on big data and digital tools available. So I would say that that's very important that you're organized and this is also something delays that the implementation of new systems. The reorganization of a city or a municipality that complicated and it has to be done between often after the election, in Sweden we have an election every fourth year. And you need to make sure that you have politicians in place to govern such reorganization. So if you would we will have election this September you know, and maybe in a year or so they are established, the politicians with the new management relations. And they can start to talk about reorganization and this will take a year to do that. And then you need to agree maybe that this reorganization will take two years and you are already past the new elections. I think organization, its super important, to make it work but it is a reorganization is complicated as well. On top of implementing big data systems.

[S56] VZ: OK, so it is a mix of this political as an organization and the structure of the city. Okay.

[S57] DM: When it comes to implementing these projects like what do you think, how do you how important is cooperation in data sharing between smart cities for for for example knowledge sharing all for for enabling these smart city resilience projects. How do you consider the importance of collaboration and data sharing?

[S58] JN: Yeah, I think it's very important because, this is one way that they can actually make sure that you know they, when they invest, they can invest together, they can have a joint program. I mean, the cities are not competing with each other, basically in this area so they can they can work together when, when developing and implementing just simple big data and they also can share knowledge on how to organize and how to operate the system and the need to have a community of people working with this big data system within the municipality, so they can make networks and they can also you know you can you can work for a couple of years in one small change in the other one, come back every year. It's important to, to work together, not just for the technology development, but also for development date and knowledge and competency pool of people and the people can see that person exactly for example you as you are students, but what are your future labor market look like, are there jobs available for you in smart city in the future.

[S59] VZ: We think so

[S60] JN: Yeah, but I mean that is something if you, you know that municipalities they have a number of different work types you.

[S61] VZ: know yeah

[S62] JN: But still when it comes to big data pretty much consultant. But the problem with using consultants as myself person is that we don't really have a good interface with the municipality of this much. We need people with good knowledge running the system being hired by the municipality, so we can interact with them. So actually look like a professional within the Smart City if you understand what I'll say,

[S63] VZ: yeah. So in that case, what would it be so you're talking about that, there is a need of people with skills and able to handle in this big data analytics concerning tools, complacency different software. So, how, how is how complex. Do you think it is.

[S64] JN: For a smart city you mean **[S65]**

VZ: Yeah, yeah, yeah.

[S66] JN: I mean, coming back to the same thing every smart city has more or less the fixed budget for the costs covered there. I mean they have taxation of the citizen and the taxation is rarely increased. So they had a budget and the budget should be split. And they have a number of activities which are found school and daycare and you know all the other stuff taken care of the and so on. And when we that they need to understand how much they should they invest in the big data. What will it cost to run it and what do they gain from having the system. Because they need to make sure that they cut costs in other ways. If they're taking the new cost for setting up and running the system and this is the explanation that But that the politician have not seen yet. The city of Helsingborg which you have talked to, they brand themselves as a digital city or a digital municipality and the metro and energy utility which is one of the bigger companies you say, public own company. They are sort of the investor in the digitalization and on top of that the city itself. But to implement big data system you need to have a good story to the manager and the politicians to present what you want. How you foresee the future. But the more cities are working together, the faster they will find a good governance model within smart cities.

[S67] VZ: Okay, so in that case is more. It's also important to focus in different cities, not just only one small city but in a collection of this working together.

[S68] JN: Exactly, I mean, taken a mobility system today, if you have a public transport system and that is built from, infrastructural thinking you know. And that this is a main road and we have stops along this main road. And we will have this capacity when it comes to capacity and number of busses etc. And they stay to that system they can monitor how many people that actually travels, but they never change anything, rather than very maybe annually or or maybe not every second year upgrade of the system. Why in other cities which don't have the public can purchase of like here in Sweden, we see that companies like uber when they see you know high demand of requests between a certain location for another destination, they can actually in a very short notice, they can put in busses instead. And this is when you see the different in working with big data for the public transport rather than working for a moral service providing strategy and this change in attitude is not here yet and the public transport. They have a business model the operators of the busses they have long term contract because otherwise they will be they will not give a contractor sort of procure the tender so so rapid changes will not happen because they they have paid you a number of trips each day from different locations instead of actually monitoring the usage towards the stop.

[S69] DM: Now that you have mentioned Uber, for example. So I understand smart city from projects that extends to cold as as well in maintaining these like. So to what extent do you think these external stakeholders contribute to adoption of technologies and what for example what how are they ready to to share, for example, to provide that access and also collaborate with the municipalities for documenting immediately.

[S70] JN: I think you are a bit away from the microphone because I'm not complaining. I hear every word.

[S71] DM: Okay, so let me speak louder.

[S72] JN: Yeah, perfect now right here.

[S73] DM: Okay, so I'm saying like you already mentioned that you give an example of Uber so I was trying to pinpoint on that and saying, to what extent do you think are the externals stakeholders influencing implementation of adoption of these innovation technologies and also how do you consider the readiness in terms for example data access in collaboration towards implementing this much projects.

[S74] JN: I think the external stakeholders. If we talk about company.

[S75] DM: Yes,

[S76] VZ: It can be private companies or it can be other organizations as well.

[S77] JN: Yeah, and I mean companies, as much as I am more aware of this and they're also number of companies that actually would like to be implemented that solutions and they are very willing to share. I have assisted, for example, car manufacture several car manufacturers that today you know have connected core system with a lot of data. I would say they are ready to share with the city's traffic management easier, but the traffic management responsibility within the city say that. Thank you very much. But we cannot act on your data. We are not allowed to present your data because we are under regulation that the real time monitoring that we could get from you has to be verified by the National Road administration and they verified

data once a year. So the smart city and the national governance system are in several ways not adapted to the new big data possibility, maybe some for the good now I mean it's good to have data verification before you present it and take it into an analysis. But on the other hand, data is available and could be useful and it's verified because I mean a car manufacturer themselves can verify it works. In smart cities is this data verification by authorities external stakeholders and present it. And we have the same thing with air quality monitoring quite interesting to see that this has been a big issue in Europe or so that the municipality of the smart city, is hard to keep up and do monitoring of the air quality. So in parallel. There is today a great network of private persons to engage and in sort of an association which they invest themselves in air quality sensors in a structured way present it on the internet to have a great sort of air quality monitoring map in real time available and which actually today. Both in us by the some of the municipalities, but they don't they're not allowed to bring this information into their reporting because it's not verified in some external stakeholders etc. That's actually they realize that you know this information is better than what we have ourselves so why not just, you know, keep it. There's a number of examples that the smart citiees themselves are the barrier to future development. If you say so. So one of my advice as a consultant is that is just set up more external stakeholder platforms and present the information presented to stakeholders within with it. It can be property owners or it can be citizens but not working together with the, I mean if you understand it, you know, working through the smart city or municipality. But if you would like to be a provider of data and data analysis through the smart city it is too slow, too problematic due to regulations and structures and organization and budget. It is better for the external stakeholders to set up their own console and work forward.

[S78] VZ: And here for example, you consider that the situation about having problems regarding two different kinds of regulations, is that recent or a challenge for this innovators that wants to work with this. Do you think this kind of stop their business models and maybe make them decide to move for a step away.

[S79] JN: I think in many ways we see a shift today. I mean I'm not the only one and advising inventors to say that don't see smart city as your client because they will have a coach at your solution or your system. For generating big data you need to come up with the business model to work sort of find a solution, a business model that brings value to the end consumer the citizen and that you have a revenue stream for that anyway. And one thing is that, for example, we spoke about noise. The noise control monitoring of noise in the city is mandatory for the city but it is done in a way it is presented in the way that you can present the noise maps and stuff like that know your sort of noise maps or stuff like that but then it's done quite traditionally. While today with very cheap microphone so much more common that you also as a system provider can present a solution where you present the noise map and the noise situation for for for people choosing schools for example, if I have to choose a school for my, my child. I can choose not to just the teachers quality but also for the outdoor quality or the air conditioning and the noise condition in this area and this information, you're find not in the municipality or the smart city pages. This is monitored outside as a service and you can also use this information when you choose your new apartment. What is the noise situation in this area? In this case the business model is that you actually work together with you. If you would like to have a part in you can purchase that that information from the noise monitoring company within the city and it has nothing with the municipality to do but it's a big data project an infrastructure for noise monitoring that is implemented by external stakeholder or a private company.

[S80] VZ: Okay, interesting. Yeah.

[S81] JN: So, I would say that, you know, the big data as it is now on thoughts. The systems and information as on, I think. And it's not just my opinion. I would say that that more and more of the big data and big data analysis will come from external stakeholders rather than the city itself.

[S82] VZ: Yeah, that's right and just, just to close with the last question. And so you have been talking about different challenges when it comes to political organizational structure in the way of making business from big data and analytics. And what about when it comes to privacy and security of data, we would like to know your perception, a bit of that.

[S83] JN: I mean, when it comes to mobility that common question isn't it. If you have a GPS tracking up a car or Yeah follow how people start off with a digital pause you use the bus or the tram systems and so on.

[S84] VZ: You think that's a challenge.

[S85] JN: sorry.

[S86] VZ: Do you think that's a barrier or the thing that's how do you perceive that

[S87] JN: I think that that will be our great thought because you must remember what I started with many of the city. They're very keen on on the security side of the big data and and there you have there were the most scary stuff if the facial recognition, that is built into more and more countries which allow, not allowed in in Europe, but with more, more cameras it is hard to stay private wwith those. So, and when it comes to monitoring of the environment, monitoring of use of of infrastructure like energy or mobility and so on. But of course, that can be neutralized. But as soon as you're going through media monitoring facial recognition and and also how we use different digital pulses or credit cards or any other stuff that can be directly related to us an individual that is. And I know for sure that many European cities are monitoring even mobile calls. They do monitor for key words or key sentences, But they are also monitoring for stress in their voices. And I mean this is some sort of terrorist and we are still under that regime. And we are allowed due to the terrible stuffs that have happened, you can use data to monitor the citizens to make sure there is no new attack. But somewhere along the line there is an integrity problem, isn't it.

[S88] VZ: Okay. Yeah. I think we are on time so so yeah

[S89] JN: so yes I am just as intrigued as you are, I guess regarding the possibilities of monitoring and big data. Where do you put the line to differ between what is good for the citizens and what is bad for the individual under the integrity as a person.

[S90] VZ: Yeah, It's a very relative answer for that question.

[S91] JN: But was it okay the interview or there was,

[S92] VZ: Yeah, it was really good. It was really good. I think we're a bit ahead of time from our side, we are basically done. Just if you would like to add something. Feel free or you feel that it was okay for you as well.

[S93] JN: No, I think I would love to meet you. But unfortunately we are a bit apart.

[S94] VZ: Yeah, Unfortunately.

[S95] JN: Well you're writing a thesis on all the interviews?

[S96] DM: I think what we are, what we are writing a thesis right now on this and I think by 29th may will be done. And we'll share a copy of what we have written to you as well, if you'd like.

[S97] JN: That would be great if I could have a copy of your thesis.

[S98] DM: Yes. So I think by 29th or 30th of May will be done and we will share a copy that we submitted to the university.

[S99] JN: Perfect. So thank you very much. Have a good weekend I will break for lunch that while someone is waiting for me outside.

[S100] VZ: Oh, okay. Sure.

[S101] DM: Thank you so much for your time.

[S102] VZ: Thank you very much and have a nice weekend to **[S103]**

JN: you too. Bye bye.

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