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The smart city – powerful but frightfully vulnerable?

A study of resilience building in high-tech societies

PART I - In search for an analytical framework

PART II - Applying the framework in urban practice

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Abstract:

Urban development has long been shaped and affected by technological development. The latest urban ideal is to invite the digital world to form the so called smart city. The smart city is arguably gaining momentum and its principles are becoming materialized in more and more cities around the world. As envisioned, this might just cast a shadow over previous technologies in terms of its ubiquitousness and its alleged potential for solving some of our times most urgent problems. However, our general concern is that the momentum and imagined solution-orientation towards urgent urban problems may override a constructive debate on whether the smart city is being rolled out in such a way as to enhance and not undermine the ability of cities to withstand and cope with stress while maintaining the ability to reorganize while undergoing change. In other words, is the smart city a friend or foe to the quest of building resilience? As a nascent urban development ideal, we think that this is an optimal time to begin mapping out challenges that the smart city poses and try to understand the societal implications thereof.

The aim of this study is divided in two: firstly, a conceptual aim to scrutinize the smart city through a theoretical resilience lens in order to identify key challenges, and secondly to complement this, an empirical curiosity on how practitioners in smart city initiatives approach some of these challenges. Due to the fact that many smart cities still are in their early stages, this study in many ways deal with potential challenges that smart cities may entail. Hence this study, on a general level, aims to explore and map out relevant aspects of resilience that potentially will become more important over time as the technological development of smart cities progresses.

This study finds that what seems to be the most pertinent challenge in building resilient smart cities is to keep pace with threats that can exploit the emerging risk landscape that the smart city give impetus to. It is nothing but a daunting task to cater to a city that in practice ought to be smart but at the same time not in danger of being frightfully vulnerable. Additionally, this study finds that it is challenging to reserve proper attention to non-functional aspects in the planning and implementation phase, such as safeguarding smart technology from various intrusions and attacks and involving citizen in the process, with consequences for resilience. This, we conclude, has much to do with the challenge of thoroughly grasping the impact of technology as a determining factor of how the city develops.

Key words:
Smart cities, Resilience, Technology, Citizens, Robustness, Flexibility

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1.0. Introduction

The digital era, in which we now live and witness, has brought about a technical revolution comparable in scale with the one who, in its time, produced industrialism. In its capacity to transform society, the digital era has made it possible to do what we already do differently in all possible sectors of society. Moreover, the digital era has introduced completely new ways of imagining, organizing and managing all kinds of societal issues (Digitaliseringskommissionen, 2016). Within urban development, the digital era has given life to a new urban ideal. The collective name for this emerging urban ideal is *smart cities*. In essence, a smart city is a conception of a city fabric whose physical infrastructure and population are increasingly enriched with information and communication technology (ICT) (Townsend, 2013). Residents, built environment and ICT intertwined help to generate large amounts of data about the city and its flows. When data is processed into information it can, as claimed, serve to optimize the way the city is organized and managed, in turn leading to increased sustainability and higher quality of life for residents (Cesana & Redondi, 2017). Internationally, PlanIT Valley in Portugal, Masdar City in Abu Dhabi and Songdo in South Korea are major urban development projects associated with this emergent urban development ideal (Hollands, 2015). Besides a global development trend, the city of Stockholm has formulated a vision and a goal: to become "the world's smartest city in 2040" (Stockholm stad, 2017a). At the Swedish national level, the government has initiated a strategic cooperation program aimed at giving an impetus to, inter alia, the development of smart cities (Regeringskansliet, 2017). In the research community, publications on smart cities are a rapidly growing trend – such that smart cities passed sustainable cities as the most common theme in 2012 (de Jong et al., 2015). All in all, the smart city seems to be an urban development ideal on the march.

It comes as no surprise that the ever-expanding and accelerating technological development and the outlet of the same in the idea of smart cities together suggest thorough societal changes. As mentioned, the smart city is expected to consist of an interwoven system of data sources – countless numbers of sensors in the physical environment as well as in residents' own high-tech utilities – connected, stored and analyzed in real time through algorithms and artificial intelligence (Kelaidonis et al., 2017). The large amounts of data are expected to generate patterns and trends that lead to more effective and sustainable decisions for the city's development. The promise of efficiency gains and better

decision-making is probably appealing in itself. However, what the smart city could give decision makers, officials and citizens is as much a fascinating thought as it reminds us of reflecting on what societies might give up in the quest for proposed merits and benefits of the smart city ideal. In general, there is relatively few critical reflections about the major implications of the technology-centered urban development ideal that the smart city phenomenon embodies. More often than not, burning questions about, surveillance, technocracy, governance and system lock-ins are left unscrutinized (Kitchin, 2015).

1.1. Problem description

As described above, the smart city is often depicted in terms of its ability to make cities more efficient. Through the advancement of technological solutions, the smart city holds promises of optimizing the way the city is organized and managed. Furthermore, the image of a clean, livable and sustainable urban life usually come in hand with the smart city ideal (Vanolo, 2016). Although certainly not promoted with the same excitement, the benefits and merits of smart cities entail a set of potential challenges. In response, critically oriented scholars have started to conceptualize these challenges and investigate their wider societal implications (for a summary see: Joss et.al., 2017). In concert with this critical body of literature, we contend that the desirability of becoming a smart city should not be viewed in absence of what risks and challenges that potentially are generated in the process. Moreover, the smart city is a nascent urban development ideal that, as of yet, often correspond with small-scale projects in practice. As such, in line with Rabari & Storper, we think that this is an optimal time to begin mapping out challenges that the smart city poses and try to understand the societal implications thereof (Rabari & Storper, 2015).

Furthermore, the smart city is arguably gaining momentum and its principles are becoming materialized in more and more cities around the world. The smart city, as the new technology-centered urban utopia, is portrayed as the solution to all kinds of urban problems (Hollands, 2015). However, our general concern is that the momentum and solution-oriented approach towards urgent urban problems may override a constructive debate on whether the smart city is being rolled out in such a way as to enhance and not undermine the ability of cities to withstand and cope with stress while maintaining the ability to reorganize while undergoing change. In other words, is the smart city a friend or foe to the quest of building resilience? Although such a fateful question may not have a definitive answer, we argue that challenges of building resilience in the smart city needs to be address. To frame the problem around resilience is, in our opinion, to be heedful as to not develop as city that is smart but perhaps frightfully vulnerable.

1.2. Research gap

Although in portion relatively small compared to the smart city research literature in general, an emerging body of critically oriented scholars have started to take interest in the smart city concept and its wider implications (for a summary see: Joss et.al., 2017). However, according to Colding & Barthel, there is a lack of resilience thinking in the wider debate on smart cities (Colding & Barthel, 2017). In so far as smart cities promote an increased dependency on ICT-systems, Ringenson et al. have highlighted that this dependency could lower the resilience of society. Firstly, ICT-systems and devices, which is becoming an ever more significant part of how cities function, are dependent on flows of finite resources and a continuous demand for energy that, when jeopardized, would reverberate into disruptions of the smart city and compromise its resilience. Secondly, ICT-systems are prone to crash in and of themselves which, if no backup is available, lowers the resilience of smart cities (Ringenson et al., 2017). However, Ringenson et al., much like Colding & Barthel, have outlined some aspect of resilience in regards to smart cities and in so doing initiated a discussion that we wish to theoretically as well as empirically advance.

Further, there has been methodological considerations as to the tendency amongst critically oriented scholar to target exceptional smart city cases. This approach would seem somewhat misguided since the majority of smart city initiatives, as Shelton et al. rightly notes, "bears little resemblance to the marketing rhetoric and planning documents of emblematic, greenfield smart cities, such as Masdar in the United Arab Emirates, Songdo in South Korea and Living PlanIT Valley in Portugal" (Shelton et al., 2015, p.14). Thus, insight into various challenges with smart cities are emerging but more empirical studies are requested (Kitchin, 2015; Shelton et al., 2015). Although Pierce & Andersson (2017) and Brorström et al. (2018), to a different extent, build on Swedish cases, applying a resilience lens on smart cities with an empirical grounding in a predominantly Swedish context seem to constitute a research gap in the literature on smart cities. This thesis aspires to fill some parts of this research gap.

1.2. Aim & research questions

1.2.1. Aim

The aim of this study is divided in two: firstly, a conceptual aim to scrutinize the smart city through a theoretical resilience lens in order to identify key challenges, and secondly to complement this, an empirical curiosity on how practitioners in smart city initiatives approach some of these challenges. Due to the fact that many smart cities still are in their early stages, this study in many ways deal with potential challenges that smart cities may entail. Hence this study, on a general level, aims to explore and map out relevant aspects of resilience that will become more important over time as the technological development of smart cities progresses.

1.2.2. Research questions

- What seems to be the most pertinent challenges in building resilient smart cities?
    - *How can a resilience framework be applied to smart cities?*
    - *What are the experienced challenges in building a resilient smart city in practice?*

The idea is that the main question can be answered by linking the two sub-questions together, this by using the first as a tool to reach an analytical framework, within which to put practical experiences from existing smart city initiatives in Sweden. Within these two questions, lies certainly a diversity of aspects and issues emerging from the complex interrelations between technology, institutions, enterprises, citizens and the urban environment citizens.

1.2.3. Delimitation

In general, this study departs from the urban scale and the internal dynamics of how the smart city develops. Resilience is here approached as a socio-technical phenomenon which highlights the hybrid nature of smart cities, where a social dimension is meant to fuse with a technological dimension on an urban scale. This, we argue, entails new complex urban interactions between technology, institutions, enterprises and citizens. This hybridization of the urban will, hence, inevitably come with new challenges when striving to build resilient cities. This study lends many concepts from the resilience terminology but where it is applied to a socio-technical interpretation of the urban dynamic. This way of approaching resilience together with this spatial confinement to the urban internal scale makes up the delimitation of this study.

2.0. Methodology

Our study is divided into two separate yet interrelated parts. The first part (Part I) is meant to approach the first research sub-question: *How can a resilience framework be applied to smart cities?* To answer this question there is a need to understand both what the smart city is as well as what resilience is. The way by which we understand the smart city and resilience is through reviewing literature as well as through interviews with persons that hold expert knowledge on different aspects of smart cities (henceforth referred to as generalists). In turn, this approach lay the basis for combining the insights from the research literature and the results from interviews with generalists. In combining these insights we derive the results to part I in our study, i.e. an analytical framework of how resilience can be applied to smart cities. Furthermore, the reasoning behind this strategy is that the analytical framework can be used as a point of departure, from which our investigation of selected smart city initiatives can proceed (Part II). More precisely, the analytical framework serves as a guide from which we derive relevant questions that we pose to the practitioners involved in the respective smart city initiatives. Accordingly, the analytical framework guides our exploration of the second research question: *What are the experienced challenges in building a resilient smart city in practice?*

Moreover, the interrelation between the two parts of the study is further expressed in that the analytical framework is envisaged as an open and evolving framework for how to understand resilience in smart cities. Thus, the analytical framework is not a once and for all take on resiliency in the smart city. On the contrary, it is susceptible to feedback from the interviews with practitioners. In other words, the empirical data from interviews with practitioners are intended to help refine the analytical framework by attesting to some aspects, bringing forth novel aspects, as well as to potentially enfeeble others. Hence, in the end of the study, strengthened by combining both theoretical perspectives on the subject as well as the empirical data from our interviewees both generalists and practitioners, we provide a concluding discussion our main research question: *What seems to be the most pertinent challenges in building resilient smart cities?* Below is a flowchart that schematically illustrates the research strategy for this study.

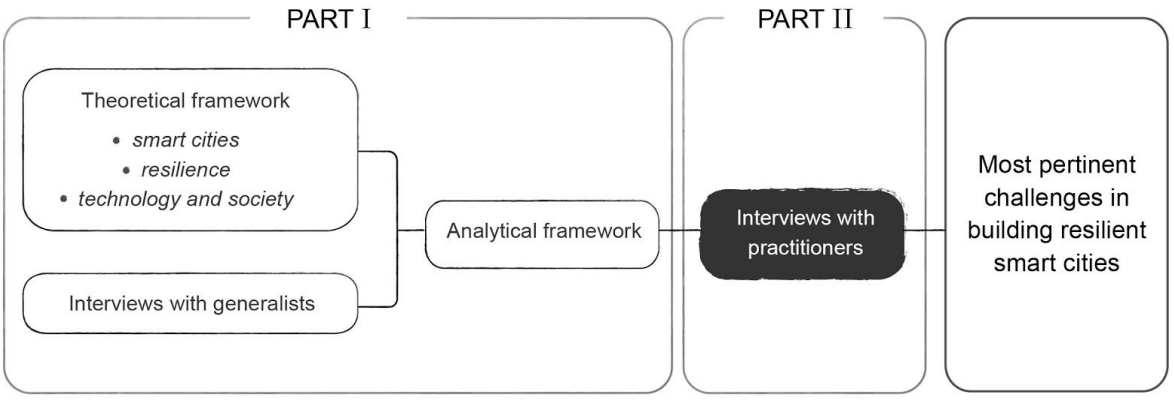

Fig. 1. Research design.

2.1. (Part I) - The basis for an analytical framework

The analytical framework, as described above, mainly builds on two sources of information: research literature and interviews with generalist. In what follows we briefly describe these two sources of information and how they influence our analytical framework. For the sake of clarity, our analytical framework is not to be equated with the quite common resilience assessments (e.g. The Resilience Alliance, 2007 a, b). The reason why we do not wish to affiliate our analytical approach with resilience assessments is, as partially touched upon already, due to the fact that smart cities is an urban ideal on the rise but where little attention has been directed to the resiliency questions. This makes a general mapping out of challenges with smart cities suitable, bridging aspects of technology and society. Further, smart cities are often of an embryonic character in the making. Consequently, we find it unhelpful to apply the rigidity of an assessment to a phenomenon that is only partly materialized and as of yet mostly at the conception stage, especially so in a Swedish context.

2.1.1. Use of research literature

In regard to the literature on smart cities, the reading had a twofold purpose. First, the literature on smart cities served as a bedrock for a basic understanding of the smart city concept. This basic understanding encompass literature on the underlying origins of the smart city concept, its more contemporary main rationales and driving motives as well as how the ideal of the smart city plays out in practice. Secondly, and in accordance with the aim of this study, we searched for literature connecting resilience to the smart city. The resulting literature was scarce. Together with Colding & Barthel (2017), we consider that the resiliency question is often entirely avoided in the conversation on smart cities. However, this is not the same as to say that the literature lack in critical reflections on challenges in

regard to smart cities. Thus, a segment of frequently occurring challenges raised in the literature on smart cities contributed to our basic understanding of the concept.

As for the literature on resilience, it is generally argued that the adoption of the term has increased significantly in academia and spread from its origin in the natural science through a number of social science disciplines (Shaw, 2012). Consequently, there are many ways to define and approach the term resilience. We approached the resilience terminology in the following way: At first a general mapping out of the concept was deemed necessary in order to understand the basic notion of what it means, how it is utilized as well as how it differs between and within various research fields. The aim of the next step was to reduce the concept to fit an urban scale and find ways it could be utilized to approach smart cities as a technological- and social phenomenon. This was not a straightforward task since the most common interdisciplinary approach within the resilience literature is on socio-ecological relations which highlights the interrelationship between human activity and ecological systems, ranging from the urban scale all the way up to planetary boundaries (e.g. Rockström et al., 2009). Resilience literature linking the technological and social dimensions were much scarcer, especially so regarding more high-tech digital technology as found in the smart city. This resulted in an approach where research on *urban resilience* proved useful in order to understand and conceptualize the urban dynamics. This was complemented with research on infrastructural resilience. This literature, however, rarely placed the infrastructure in a social context. In order to capture the interplay between the social and technological we also consulted useful theories from research such as *socio-technical systems theory* and *philosophy of technology*.

2.1.2. Interviews with generalists

As part of this study, we've conducted four interviews with persons that hold expert knowledge on various aspects of the smart city. These interviewees are called generalist due to the role they play in our study, namely as informants that provide general input on the subject of smart cities and resilience. The main reason why we conducted these interviews is because they could complement the research literature in several ways. Firstly, the research literature on smart cities in a Swedish context is scarce. Here, the interviewees, being both relevant to the subject as well as based in Sweden, were seen as a valuable input on the condition of smart cities in a Swedish context. In particular, Mattias Höjer and Anna Kramers, both researchers at the Royal Institute of Technology in the city of Stockholm, fit these criteria. Apart from a researcher with interest in the role ICT plays in urban sustainable development, Höjer is a member of the Swedish Government's national

innovation partnership program on smart cities. With similar research focus as Höjer, Kramers wrote, amongst many things, her dissertation centered on smart cities. Further, together with the smart city, a key concept in our study is resilience. Here, Johan Colding, researcher at Stockholm Resilience Center, was recruited as an interviewee that is knowledgeable about the field of resilience research. In addition, Colding, together with a colleague at Stockholm Resilience Center, recently published an article outlining some general resilience questions in regards to the development of smart cities (Colding & Barthel, 2017). As the article is more of an introduction to the topic, we interviewed Johan Colding to get a more comprehensive view of how he reasoned in regard to resilience in the smart city. Apart from substantiating our understanding of both the resilience and the smart city concept, as well as how these two may go together, Johan Colding put us in contact with an expert on cyber-security and the internet of things, namely his brother Magnus Colding. As has become and still is central to our understanding of the smart city is the focus on modern technologies as an integral part of urban development. As Townsend bluntly puts it: "The old city of concrete, glass, and steel now conceals a vast underworld of computers and software" (Townsend, 2013, p. xii). As students of geography and urban planning, we're more familiar with the city of concrete, glass and steel. Less so with that potentially emerging underworld of computers and software. To this latter part, Magnus Colding were deemed as a valuable interviewee in so far as he could provide a basic understanding of what the increased focus on modern technologies could entail in terms of risks and vulnerabilities, both in general and in particular.

Name	**Profession**	**Connection to smart cities and/or resilience**
Johan Colding	Associate Professor at Stockholm Resilience Centre and University of Gävle	Co-author of an article on smart cities partly from a resilience perspective (Colding & Barthel, 2017) as well as a researcher on resilience in general
Anna Kramers	Researcher at the Royal Institute of Technology, Stockholm, Sweden	Doctoral thesis: "Smart Cities and Climate Targets; Reducing cities' energy use with ICT and travel information"
Mattias Höjer	Professor at the Royal Institute of Technology, Stockholm, Sweden	Member of the Swedish Government's national innovation partnership program on smart cities
Magnus Colding	Certified instructor and consultant in the IT-sector, Sweden	+20 years of experience with the IT-sector and currently involved in issues of cyber security in smart cities

Table 1. The generalist informants and their connection to smart cities and/or resilience.

2.1.3. Data collection: generalists

As mentioned above the idea of conducting the interviews was to complement the research and hence widen our understanding on several subjects. In order to widen our understanding, we approached the interviews based on themes and open questions. This semi-structured interview approach allowed for some direction while also allowing for flexibility in order to capture aspects and connections that the interviewees regarded as relevant (Longhurst, 2009). These interviews, as previously mentioned, were meant to explore and identify what smart cities are, its potential vulnerabilities, as well as how they relate to the concepts of resilience. We approached these interviews by firstly aiming at framing the smart city: What is smart cities both in general and in the Swedish context. Here we aimed at capturing aspects such as: main driving forces, main rationales, main differences between practice and research, etc. The second part aimed at capturing the different actors and their interrelations. Here we approached questions on institutions, citizens, enterprises, as well as technology. Lastly, we approached questions of vulnerabilities and resilience in regards to smart cities. This part reflected back to the previous answers they gave, which we argued, would give a general picture of how smart cities and the actors involved interrelates to questions of vulnerability and resilience. The interview with Magnus Colding also approached themes of more technological character, focused on how modern technologies interconnect and the potential risks associated with implementing this on an urban scale.

2.1.4. Data processing and analysis (generalists)

The data from these interviews were transcribed and categorized under the various previously mentioned themes. From there we could derive some sub-themes which were regarded as interesting for how we could approach the aim of this study. As part of this process, we could compare the data from the different interviews and analyzed their main similarities and differences. Such sub-themes substantiated aspects already explored in the research literature as well as guided our exploration of the research literature in new directions. Altogether, this gave us a broader picture of how smart cities develop, the main actors and potential risks and vulnerabilities. These themes and categories could then be placed next to the research literature which in the end would guide our endeavor in developing the analytical framework.

2.2. (Part II) - Applying the framework to a Swedish context

In this part of the chapter we describe and discuss various methodological decisions in regard to the smart city initiatives studied. The idea is that the analytical framework, from part I, gives a guideline to what resilience aspects that might come of interest when developing smart cities in practice.

2.2.1. The selection of smart city initiatives

The overarching aim of this study is to understand challenges that the smart city poses in terms of building resilience. It is worth reminding that the subject area of smart cities linked to resilience is relatively unexplored. Therefore, we consider that there is room for, at a fairly general level, to map out challenges for resilience building within the urban development ideal smart city. Subsequently, it is more in line with our aim to target several smart city initiatives rather than an in-depth case study of one in particular. Following this point of departure, cities that have some experience with working towards a smart city ambition in practice are, in our opinion, most suited to guide our investigation. Thus, the criteria in selecting cities to study was that they displayed smart city ambitions, not only as a fuzzy goal but as implemented projects in practice. Following these criteria, we aimed to select cities that seemed to have got the farthest in implementing their respective smart city initiatives. Supposedly, such cities would better inform our study since they have a more substantial experience to depart from. With this criteria in mind, a preliminary exploration of smart city initiatives seemed to suggest that the Swedish context provided less mature smart city projects and that an international outlook would be the most appropriate support for our thesis' purpose. However, for whatever reason, international smart city representatives were harder to get in contact with and less willing to partake in our study.[1] Finally, the city of Oulu, Finland, and Eindhoven, Netherlands, agreed on an interview. However, both Oulu and Eindhoven responded fairly late and serves as a more general international outlook on the development of smart cities. We will return to the purpose of including representatives from Oulu and Eindhoven later on.

Due to the lack of success in recruiting more international smart city initiatives, the Swedish smart city context was explored in more detail. A handful of Swedish cities fulfill the criteria of implemented smart city projects; notably Stockholm, Helsingborg, Lund, Gothenburg, Skellefteå and Umeå. In the end Stockholm, Helsingborg and Lund were

[1] Cities that are working on smart city projects and were of interest to our study but declined to participate are Antwerpen, Amsterdam, Rotterdam, Hamburg, Copenhagen and Glasgow.

selected as appropriate candidates because they have ongoing smart city projects that are materialized in the city, staff catering to both strategic and more practical issues, as well as an agreeableness to participate in the study.

In sum, we argue that Stockholm, Helsingborg and Lund provide a fairly valid outlook on the state of the art of smart cities in a Swedish context. Thus, in the Swedish context this provides one prerequisite for mapping out challenges in building resilience in the smart city is achieved. In the following we elaborate on how we studied the selected smart city initiatives.

2.2.2. Data collection: interviews with practitioners

In order to target resilience in smart cities, semi-structured interviews with practitioners implementing smart city solutions was our main mode of procedure. There are at least two reasons behind choosing semi-structured interviews with practitioners as our method for data collection. Firstly, the city of Stockholm is the only city amongst those selected that has publicly available documents elaborating on the cities' smart city strategy. Thus, the source material suitable for text analysis methods was deemed to scarce. In response, directly engaging with practitioners working on the respective smart city initiatives was seen as a more fruitful way of working towards our research aim. Secondly, closed questionnaires or structured interviews would arguably be less inclined to foster a relationship of learning and discovery that we seek to establish between our analytical approach and empirical data. Semi-structured interviews, on the other hand, have that strength as a method and are more in line with the exploratory nature of our study (Longhurst, 2009). The interview guide is presented in Appendix I. In short, the interview guide encompass a set of questions that are derived from the analytical framework presented in the chapter *4.0.*

The interviewees from the three municipalities were chosen on the basis that: one, they showed an explicit involvement in the respective smart city initiatives (e.g. contact on the smart city's web page or appointed through the snowball effect); two, they represent a city or municipal body. The first criteria are more self-evident, i.e. we wish to interview those who are supposed to be informed on the subject. The second criteria are less self-evident and needs some elaboration. Although municipalities do not develop the smart city by themselves in isolation – e.g. they need the ICT industry as providers of smart technology and need to relate to the state and national laws as an overarching framework – they are more likely to assess the role of a main actor insofar as they are accountable for the administrative area in which the implementation of the smart city solution takes place, in a short as well as a long-term perspective. In our smart city initiatives, the municipality do

have this strategic and practical role. Elsewhere in Europe, it has been shown that municipalities often assess this role of project coordination in smart city projects (Pierce & Andersson, 2017). Thus, the municipality is regarded as the actor who is most likely to possess a holistic view of the smart city projects in questions and accordingly the one who is most suitable to reflect on challenges with building resilience in their respective smart city project. Below is a summary of the interviewees that fulfilled these criteria. The interviews lasted for 45 min. to 75 min. and were conducted at the interviewees' workplace or by voice calls. All interviewees gave us permission to record the interviews and to use their name in the study.

Name, city, country	**Profession and role in respective smart city initiative**
Björn Lahti, Helsingborg, Swe	Official at the Urban planning department and project manager for Smart@Helsingborg.
Andreas Hall, Helsingborg, Swe	Official at the Urban planning department, working with maintenance and operation in regard to Smart@Helsingborg.
Johan Martinsson, Helsingborg, Swe	Sales- and marketing manager at Öresundskraft, municipal owned energy company, with a focus on smart city development in Helsingborg.
Peter Kisch, Lund, Swe,	Project manager at Future by Lund, an innovation platform hosted by Lund municipality and Vinnova.
Anders Trana, Lund, Swe	Project manager for Smart public places at Future by Lund, an innovation platform hosted by Lund municipality and Vinnova.
Janette Palm, Stockholm, Swe	Official at the department of Digital development, the City Executive office of Stockholm. Holds the position of IT-architect and working on implementing the city of Stockholm's Smart city strategy.
Claes Johannesson, Stockholm, Swe	Official at the department of Digital development, the City Executive office of Stockholm. Working on implementing the city of Stockholm's Smart city strategy.
Gustaf Landahl, Stockholm, Swe	Head of the Environment department, Stockholm, and coordinator for GrowSmarter, an EU project on smart city solutions.

Table 2. Practitioners and their role in respective smart cities initiative.

Lastly, at the end of each interview we asked the interviewees if our themes and questions were understandable, relevant, misguided and/or if we have neglected some important aspects. To some extent, this feedback feature was seen as important for enhancing the reliability and validity of our interview guide. If the interviewee perceived the interview-guide as understandable the questions were deemed as a more reliable instrument for our study. Additionally, if the interviewee perceived the interview-guide as relevant the questions were deemed as more valid. This however comes with potential downsides that needs to be considered. It is not necessarily so that our interviewees' feedback is

well-founded, hence it was not taken at face value. Rather it was approached by further questions to find out how and why. All in all, this feedback feature enables us to develop a relationship of learning and discovery between our analytical framework and empirical investigation.

2.2.3. Input from the national and European level

Initially, our intention with the study, as discussed previously, was to target cities that have gotten the farthest in their respective smart city development. In exploring the field of smart city projects, an international outlook would be more appropriately in line with this intention. However, one representative from the city of Oulu and one from Eindhoven, the two international smart cities that were willing to partake in our study, were recruited fairly late and through the snowball effect in conversation with the smart city strategist in Helsingborg (B. Lahti, personal communication, 11 jan. 2018). Both these representatives are engaged in the conversation on digital transitions and smart cities at a European level. Moreover, Eindhoven, together with Manchester and Stavanger, are so called lighthouse cities in the evolution of the smart city idea. Funded by the EU project Horizon 2020, lighthouse cities basically means being a forerunner in implementing smart city projects (Triangulum, u.d.). In our study, the representatives from Oulu and Eindhoven are seen as valuable points of reference to a wider European context. The combination of being recruited later on in our study and the role they play in the smart city context are the primary motives for assigning the representatives from Oulu and Eindhoven relevance in our study.

In the same line of thought, we also looked to points of reference on a national level. Herein, the Swedish Civil Contingencies Agency (MSB) was seen as a valuable input since they stress the need for resilience on multiple levels in society as one central part within the agency's general responsibility for issues concerning civil protection, public safety, emergency management and civil defense (MSB, 2013b). At MSB, Carl Önne, an official at the Cybersecurity and Critical Infrastructure Protection Department, was recruited as an informant that potentially provides a more general perspective on certain parts of the smart city development.

Name	Profession
Mika Rantakokko, Oulu, Fin	Official at BusinessOulu, city of Oulu business development agency and coordinator for the EU Urban agenda Digital transition partnership.
Jonas Onland, Eindhoven, Nld	Official at the city of Eindhoven and program manager of the EU project Urban agenda: Digital transition partnership.
Carl Önne, Swe	Official at the Cybersecurity and Critical Infrastructure Protection Department, at MSB.

Table 3. Practitioners with a national or European outlook.

2.2.4. Data processing and analysis

Data from the interviews have been processed and analyzed based on a qualitative content analysis. This method is, according to Denscombe (2016) well suited to examine attributes and characteristics of data. The general idea is to approach data in a systematic manner to allow for certain patterns and themes to emerge connected to the aim of the study (Esaiasson, 2007). Processing and analysis of data was approached through several steps. Firstly, relevant parts from our recorded interviews were transcribed. The first general categorization was then done by following the various themes from our interview guide. The next step was a further condensation of data, this to extract those parts that were considered important (meaning-bearing) based on the aim of the study. At this point we followed a so-called *mapping method* where the main themes from the interview guide is divided into categories and subcategories (Esaiasson 2007). Under every theme and subcategory, we highlighted and summarized the main points of interest but where most data were maintained in its original textual context, this to not misinterpret the general meaning and also in order to reliably combine and compare categories between different interviews, which was the next step. The combination of themes and subcategories later formed the basic picture presented as results.

For the analysis it is also relevant to explain at what depth information has been analyzed. The researcher can be said to interpret data on two different levels, latent and manifest (Esaiasson 2007). A manifest meaning is a more direct account of what is said in interviews, while a latent sentence refers to underlying sentences that require a deeper interpretation (Graneheim, Lundman 2014). In our case, we focus on manifest sentences because we primarily consider our interviewees as informants and not respondents. In other words, we approach the interviewees as representing their organization, hence informants, rather than as private persons.

2.2.5. Methodological discussion

Clearly, in this part of the study, where we explore what challenges that are experienced in building a resilient smart city in practice, interviews are the method we use. Previously, we elaborated on the motives behind this choice of method, primarily centered on the strengths of the semi-structured interview in relation to what this study aims to do. However, the interview as a method for social science research is far from a simple technique used to tap the interviewee on their knowledge about their situation, be it personal information or experiences in a work situation. In a clear and elucidatory way, Alvesson argues for the importance of not simplifying and idealizing the interview situation, assuming that:

> "[...] the interviewee [...] primarily is a competent and moral truth teller, acting in the service of science and producing the data needed to reveal his or her 'interior' (i.e. experiences, feelings, values) or the 'facts' of the organization." (Alvesson, 2013, p. 14)

On the contrary, according to Alvesson, the interview situation should be viewed as a complex social situation. In general, we agree with Alvesson's critique. In this study, we've approached several different smart city initiatives in different municipalities and in each and every one of them several different informants. This approach makes it possible to critically compare the results from several different informants. In response to Alvesson's critique, we argue that this approach reduces the risk of a situation where one relies on one or few informants as competent and moral truth tellers.

In the end we argue that all data from interviews together with the analytical framework, developed in part I, gives a good indication to whether or not various questions are perceived of as reliable and valid.

3.0. Theoretical framework

In this chapter we intend to develop a theoretical framework that lend itself to the overarching aim of this study. In so doing, we start by more thoroughly introducing the smart city concept. Further, we elaborate on some critical interventions on the smart city. Amongst the critical interventions on smart cities few if any attempts of developing a framework for resilience thinking has been made, however, those that we elaborate on in this chapter reveal certain aspects that in our opinion has bearing on resilience and are worth pondering on. Thereafter, in order to develop our understanding of resilience, we present a general notion of resilience thinking. In addition, we focus on the key concepts of robustness and flexibility as a way to support our understanding of resilience beyond a general notion. These key concepts will be highly instrumental in the following chapter, i.e. when we develop our analytical approach to resilience in smart cities. Finally, we introduce a set of theories that could complement resilience theory, and which are elaborated on in the following chapter.

3.1. The smart city

What is a smart city and how can it be understood? As could be expected of a fairly new concept, neither the research literature or sources that issue from public authorities convey a firm definition of the smart city (Krivý, 2016). At first, a glimpse at real life smart city endeavors seems to further enhance the confusion of ideas. For example, both the extensive "control and command room" in Rio de Janeiro, developed by IBM, and an application gathering information on tourist sightseeing in the city of Helsingborg label themselves as smartening the city. Notwithstanding all that which makes one city different from the other, a common denominator for smart city initiatives is the strive for increasing the interconnectedness between information and communications technology (ICT), the built environment and citizen (Klauser et.al., 2014; Picon, 2015; Pierce & Andersson, 2017). Typically, one can conceive of the smart city as composed of numerous sensors integrated into the physical urban fabric. Such sensors, connected and communicating through different ICT-networks, gather all kinds of data that can be processed and analyzed and finally displayed on platforms (Rabari & Storper, 2015). To put it more bluntly: "The old city of concrete, glass, and steel now conceals a vast underworld of computers and software" (Townsend, 2013, p. xii). To further understand the subject of this thesis, this chapter starts

by outlining the more contemporary driving motives and main rationales behind the smart city concept. Altogether, this introductory section will nuance our understanding of what the smart city is. Following this, we delve deeper into some concerns present in the emerging body of critically oriented literature on smart cities. In their own way, these concerns point to challenges in the smart city that resonate in large with resilience thinking.

3.1.2. Smart city - main rationales

The smart city is a relatively new concept and on the rise. According to a comprehensive bibliometric analysis conducted in 2015, the smart city concept, judged by its frequency of occurrence in academic journals, "appears to have become an increasingly dominant category of urban modernization policy", in fact, to such a degree that the concept surpassed the umbrella concept of sustainable city in the year 2012 (de Jong et al. 2015, p. 1). As already been touched upon, the smart city concept often adheres to the notion of improving "the ability to forecast and manage urban flows and push the collective intelligence of cities forward" through a hybridization of smart technology, built environment and citizens (Schaffers et al., 2012, p. 434). In short, the smart city concept endorses technology as the driver for change and the solution to urban problems faced in the 21th century (Marvin et al., 2016, p. 3).

In the eyes of large ICT-firms, whom are enabling the deployment of smart technology, the message is that smart cities can simply, as Townsend puts it, "do more with less, and tame and green the chaos of booming cities" (Townsend, 2013, p. xiii).[2] Although in a more modest way, the applied research on smart cities, focusing on problem-solving in technical, engineering and economic terms, share this overarching objective, i.e. the potential to increase the effectiveness of city government via smart city solutions. Common use cases are the potential to remediate urban mobility issues (e.g. traffic jam and parking management); reduce energy use and waste disposal; monitoring air and noise pollution; developing applications for public participation; public safety and security through surveillance (Domingue et al., 2012; Gertman et al., 2015; Peris-Ortiz et al., 2017; Dustdar et al., 2017).

Furthermore, as a general recommendation, the European Innovation Partnership on Smart cities and Communities (EIP-SCC), a funding instrument within the EU Commission, highlight the benefits of striving towards integrated infrastructures in the quest for making cities smart. Ideally, the smart city integrates new and existing infrastructure networks by

[2] See for example the Cisco report "Is your city smart enough?" for an illustration of this line of argument. https://www.cisco.com/c/dam/en_us/solutions/industries/docs/Is_your_city_smart_enough-Ovum_Analyst_Insights.pdf

exploiting modern technologies and in so doing avoids needless duplication. The smart lamppost is illustrative as it no longer not only provide lighting but also Wi-Fi, monitoring sensors and CCTV (EIP-SCC, u.d.). As the term implies, smart cities target the city scale and as such the ideal is to be viewed as "a whole body of systems, i.e. system of systems" where the interrelationship between different smart city domains is a salient feature (Osman et al., 2017).

Additionally, in instrumenting and interconnecting the built environment and citizens with the help of smart technology, often enabled by the diffusion of sensors and wireless sensor networks, it is anticipated that the smart city will generate huge amounts of real-world urban data (Pierce & Andersson, 2017). In turn, when collected and analyzed, this real-world urban data will potentially improve the ability to address and respond to multiple urban challenges of which the previously mentioned use cases are just a small selection (Schaffers et al., 2012; Martucci et al., 2017). Moreover, the smart city often comes in hand with a powerful rhetoric offering, according to Vanolo, "the image of clean, liveable, technologically advanced cities […]" (Vanolo, 2016, p. 894). The main rationales of the smart city, despite its promises of efficiency gains and more informed decision making, often beg the questions of wider social, political and economic ramifications. In what follows we will delve deeper into concerns of societal implications, focusing especially on those which centers on risks and vulnerabilities of incautiously advancing the development of smart cities in the way we described above. In turn, as will be demonstrated later, these concerns have bearing on our departure in resilience theory.

3.1.3. Smart but buggy and brittle

In the port of Rotterdam, striving to be the smartest in the world, the fully automated APM Terminal serves as the flagship model for the Danish shipping giant Maersk. In the end of June 2017, the terminal was infected by an unintended malware attack. The cyber-attack brought the terminal to a halt with lots of negative consequences where costly delays hampering the daily operations of transport and trade in the largest port in Europe was possibly the most significant one of them (DutchNews.nl, 2017; NL.Times.nl, 2017). Two years earlier, the US Federal Drug Administration dismantled a computerized infusion pump because it "could be accessed remotely through a hospital's network […]" (Asplund & Nadjm-Tehrani, 2016, p. 2132). In the automotive sector the same year, two hackers demonstrated that they could turn off the engine of a Jeep by accessing its digital system through Internet (Wired, 2015).

Beyond domains of more or less critical societal infrastructures there has been reports on numerous cyber security concerns with regard to those devices and gadgets that compose our civic infrastructure and that are so integral to the smart city (e.g. Costin et al., 2016). Here, the smart lamp post is an illustrative case. In being smart, the lamp post bridges the virtual and physical world, allowing light to be controlled remotely from a smartphone; collecting environmental data through sensors; providing Wi-Fi connectivity; etc. (EIP-SCC, 2018). Notwithstanding the promising possibilities, this process of making smart has arguably introduced a new set of vulnerabilities. In regard to remotely controlled light, as Ronen & Shamir detail, bridging the physical and virtual world entails that the functionality of lighting can be corrupted in several ways through attacks. Such attacks can be clustered into four categories which, according to Ronen & Shamir, apply to most smart city devices. Briefly, the first cluster of attacks regards the smart devices as the best attack vectors in a network. Here, the intention is to exploit the minimal security protection of smart devices to damage, for example, computers connected to the same network. As opposed to the first cluster of attacks, the other cluster of attacks are directed at the intended functionality of the smart devices: reducing the functionality (e.g. lights will not turn on); misusing the functionality (e.g. lights are turned on when not wished for); extending the functionality (e.g. lights are used in an completely different and unexpected way) (Ronen & Shamir, 2016).

In the extensive list of cyber security threats disclosed, this small portion of examples testify to the main point: software technologies are inherently "buggy and brittle and are prone to viruses, glitches, crashes and security hacks" (Kitchin et al., 2016, p 19). In regard to smart cities, the general concern is quite simple. As we embark on developing smart cities, which in essence enhance the conflation of digital systems and the city, will the buggy and brittleness of today's software environments become endemic to the urban way of life? What seems to be evident is that the smart city introduces a new risk landscape with a different and larger attack surface. Consequently, this entails a serious consideration whether the old defense strategies are up to date (Asplund & Nadjm-Tehrani, 2016).

In a wider perspective, in a society dependent on digital systems with no manual counterpart, which is very much the case already today, "software is the difference between something happening or not" (Kitchin & Dodge, 2011, p. 10). In such scenarios, software and space have become, according to Kitchin & Dodge, mutually constituted so that if a software fails, space is not produced as intended. The computerized cash registers in supermarkets are an example. If the IT-system behind the cash registers crashes, goods can no longer be purchased, and in a functional sense, "the space effectively ceases to be a supermarket instead becoming a temporary warehouse" until the IT-system is reactivated (Ibid., p. 17).

Thus, depending on what societal function that is mutually constituted in this way, the buggy and brittleness of software technology can have tremendous societal consequences.

3.1.4. Smart cities as an untapped market

As of today, it comes as no surprise that neither local nor regional or national public authorities have the capacity to develop the hard- and software technology of the smart city. Accordingly, most of the technical issues of the smart city is developed and controlled by private companies (Pierce & Andersson, 2017). Thus, the driving force occupied by the ICT industry, dominated by big vendors like IBM, Cisco, Siemens, Philips and the like, has emerged as a power and politics issue in regard to discussions on smart cities (Townsend, 2013; Kitchin, 2015; Hollands, 2015; Vanolo, 2014). Previously supplying the private sector with integrated IT-solutions, it is argued that major ICT firms now set their sights on "government as a huge, untapped market and cities as a particularly high-growth segment" (Townsend, 2013, p. 64). For example, in 2010 IBM launched a program that was called the Smarter Cities Challenge. Within this program, cities can compete in winning a collaboration with an IBM team of experts in smart city solutions tailored for the winning cities' needs (IBM, n.d.).[3] One concern is that public authorities will end up in vendor lock-ins where one or few private companies provide all-encompassing solutions that creates a "corporate path dependency that cannot easily be undone or diverted" (Kitchin, 2015, p. 10). Although smart city initiatives differ in a multitude of ways depending on where they are grounded and that it is prudent not to imply that one version of the smart city is more predominant than others, it nonetheless seems reasonable to develop an attentiveness towards questions of whose interests are served in the smart city and possibly to what cost. To some extent, it goes without saying that those actors who own, control and develop the smart infrastructure have a greater opportunity than others to capture and shape the smart city for their own gain. Arguably the supply and demand relation between the private ICT providers and the public authorities, which the smart city accentuate, requires regulatory tasks on behalf of public authorities. There are concerns whether such capacity (e.g. expertise and resources) exists amongst public authorities (Taylor Buck & While, 2015).

3.1.5. Governing through code

The appeal of smart cities is, as has been outlined earlier, that a wide range of smart technologies can be utilized to improve planning and management in several city domains.

[3] Other examples include Microsoft's CityNext (Microsoft, 2018) and Arup's Smart cities services (Arup, 2018).

The catalyst in so doing is the ability to collect and process data that is generated by numerous smart devices (e.g. sensors, actuators, smartphones, smart cars, smart buildings and its home appliances). Already in our digital times of today, data and the way we make data intelligible through algorithms and other data processing techniques is playing a more central role as the basis whereon decisions are made (SOU 2016:85, p. 34). A general concern is then who can read, interpret and display data and on what parameters, in what context and under what considerations? According to Picon, the relation between actors in the city (e.g. citizens, public officials and decisions-makers) are potentially tilted by the necessity of introducing evermore technical supervision on the matter of evermore smart services (Picon, 2015). Underpinning this concern is the notion that data and algorithms are not only helpful tools in the quest to greater knowledge about the city but also in itself inherently performative (Klauser et al., 2014). In other words, there could be a tendency to value and act upon what we can measure rather than measure what we value. The advancement of computational approaches to urban problems will, several scholars suspect, lend itself to certain political and spatial arrangements (e.g. Gabrys, 2014; Joss et al., 2017; Klauser et al., 2014; Leszczynski, 2016; Rabari & Storper, 2015).

In regard to the role of urban citizen, Gabrys suggest that the smart city portray the citizen as yet another data point, "both as generator of data and a responsive node in a system of feedback" (Gabrys, 2014, p. 38). Although this more passive role occurs elsewhere, as evident in the more recent UK smart city context, Joss et al. adds the active role of citizens as users of data. In short, this active role entails exploiting data for developing new applications that could support community needs to data as the medium for more informed decisions and ensuring accountable governance (Joss et al., 2017).

3.2. Resilience

During the last decade, the concept of resilience has arguably become a salient feature of urban studies and practice. The adoption of the term has increased significantly in academia and spread from its origin in the natural science through a number of social science disciplines (Shaw, 2012). What is more, building resilience has also become popular amongst different policy makers and non-state actors alike, from supranational organizations like the UN to national and municipal governments, down to bottom-up initiatives by local communities (Sellberg et al., 2015). It has been argued that resilience thinking is timely given that in recent time's severities such as extreme weather induced by climate change, terrorism and uncertainty of social and economic progress has increased in frequency rather than peter out (Davoudi, 2012). Why resilience has risen as a timely conceptual as well as

practical corrective to many societal challenges is partly because at the heart of resilience thinking is the search for the capacity of a system, be it natural, social or social ecological, to absorb perturbations and shocks as well as to reorganize and develop under circumstances of stress (Colding & Barthel, 2017; Walker et al., 2004). Situated within this context, this partly explains why resilience, much like sustainability did before it, is rapidly becoming a part of the planning and government policy lexicon (Davoudi, 2012; Shaw & Maythorne, 2012).

In the conversation on smart cities, according to Colding & Barthel, "the resiliency question of the Smart City-model is often entirely avoided in the current debate" (Colding & Barthel, 2017, p. 97). When resilience is mentioned it figures as a partial aspect amongst many potential merits of the smart city, for example, the ability of sensors to better alarm during adverse events, rather than as an overarching characteristic of the smart city (EIP-SCC, n.d.). In so far as the smart city is understood as an ideal that nourishes the idea of embedding smart technology in the built environment and aims to, together with residents' personal high-tech devices, increase the conflation between digital and analog systems, questions of how this relates to resilience would seem to encompass a wider outlook. Risks and vulnerabilities in regard to software technology, a fundamental component of the smart city, as discussed in the section *Smart but buggy and brittle*, supports this claim. Thus, to tentatively put it in resilience terms, buggy and brittle smart technology is potentially an aspect that could jeopardize the smart city's capacity to absorb shocks and maintain its fundamental functions. Another aspect that will become of great importance is how well smart cities can be incorporated and integrated with existing society and all its complexity.

Before elaborating further on that which our analytical approach aims to capture, i.e. the various ways in which the concept of resilience come in useful as a lens to apply on smart cities, there is need for a more thorough exploration of the concept of resilience. In so doing, the first part of this section deals with the resilience terminology in general. This general layout is followed by elaborating on key concepts that constitute the complex pathways to resilience.

3.2.1. Resilience - a general layout

The general notion of the term resilience is captured in the definition provided by Walker et al (2004, p. 1): "Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function". In short, this notion denotes both robustness, as in absorbing disturbance, and flexibility, as in reorganizing under change. At this basic level the meaning of resilience is often agreed upon within various research fields (Davoudi, 2011; MSB, 2013b), however, despite this consensus

as to the general notion of the concept, there are a plethora of ways to approach it (Dekker et.al 2008, MSB 2013b).

In fact, this has been argued to both the strength and weakness of the concept. For example White & O´hare (2014) argues that resilience when applied to social systems in some sense loses its value due to this vagueness and hence becomes a tool for striving for status quo. This critique against resilience reflects the desirability of returning to a previous state, what many definitions describe as for example "still retain essentially the same function" and "without losing fundamental functions". One could hence claim that resilience in some sense entails a stance connected to the continuity of a certain system. Pendall et al. (2010) describes this as an emphasis to return to a normal state without questioning what this state entails. Resilience, hence, is in a sense not an apolitical stance on a system's property. For instance, someone might perceive of a society as a way of upholding unsustainable lifestyles and/or creating illegitimate power structures, for instance, through our economic system (Hornborg, 2009; Davoudi, 2011). One way to approach this issue has been to perceive of resilience, when applied to social systems, as a complex adaptive process where emphasis lies on maintaining functions of a system and not on keeping the system itself intact (Meerow et al., 2016; Desouza & Flanery, 2013). This way of approaching resilience has been applied to many fields one of these being *urban resilience* (Meerow et al., 2016) which becomes of great relevance to this study.

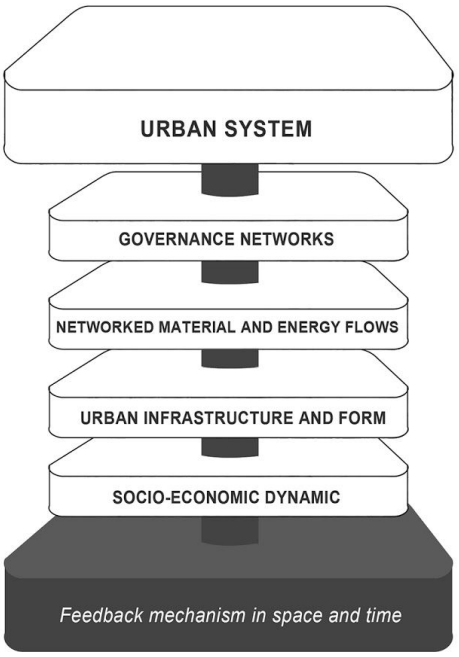

Fig. 2. Simplified conceptual schematic of the urban system. Inspired by Meerow et al. (2016)

Urban resilience is by no means a homogeneous field of research however the focal point lies in the dynamics within the city while simultaneously acknowledging external relations and dependencies (Meerrow 2016; Desouza & Flanery, 2013). Meerow et al. define urban systems through the resilience terminology as: "Complex, multi-scalar systems composed of socio-ecological and socio-technical networks that encompass: governance, material and energy flows, infrastructure and form, and social-economic dynamics." (Meerow et al., 2016, p 45). Applying resilience to this kind of system requires a view where resilience is perceived of as an evolutionary process lacking a fixed state that can be called resilient, this for both practical and normative reasons. The practical reasons refer to whether or not something as complex and dynamic as a city can be perceived of as having a post-disturbance state to return to since all parameters will change together with the disturbance (Klein et al., 2003). This leads to the normative reasons where no one person or group should single handedly define what resilience means for a city once and for all. Rather this also should reflect on the dynamic processes of the urban dynamics touched upon in fig. 2 above.

This evolutionary view of resilience is described by Desouza & Flanery (2013) as consisting of object and agents giving rise to both predictable and unpredictable patterns. They go on to argue that if one is to approach resilience both in theory and practice one should strive towards understanding both components and processes:

> *Planning for resilience to the impacts of stressors within cities requires an evaluation of the vulnerable components of cities, an understanding of the key processes, procedures, and interactions that organize these components and develop the capacity to address various structuring of components and their interactions with the ultimate goal of achieving resilience. (Desouza & Flanery, 2013, p 89)*

In sum, the thought with resilience is that no system can uphold status quo and hence need to be able to adapt to new conditions, i.e. stress. A failure to adapt to various stressors will lead to the collapse of a system which hence, from a resilience perspective is to be considered a failure of the current system. However, the adaptability of a system consist of a multitude of levels where a collapse in one subsystem does not necessarily reflect on the overall capacity. In fact, various degrees of systems flexibility is, for example in socio-ecological resilience, considered necessary to the overall resilience: "simply trying to make systems more robust to changes may lead unsustainable systems to resist over time" (Folke et.al., 2010; Chelleri, 2012). Resilience is hence in need for both robustness and flexibility, where robustness can be seen to describe an ability to stay on a certain course and withstand various stressors (see top arrow in fig 3 below). However as previously discussed,

on the urban level there is also a need for an evolution of the system, where an ability to change functions or get rid of them all together is necessary. This is called flexibility which implies that systems can undergo change in order to adapt and evolve together with changing circumstances (see bottom arrow in fig 3 below). Chelleri (2012) here argues that the magnitudes of flexibility can be divided into two levels: *transition* (system incremental change) and *transformation* (system reconfiguration).

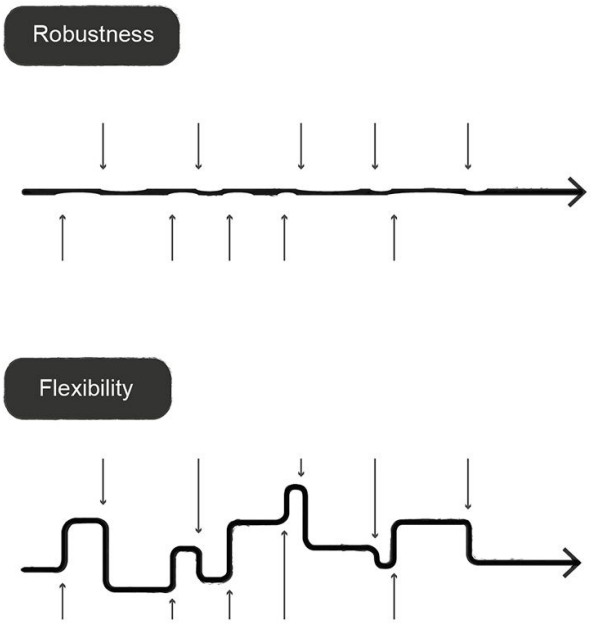

Fig. 3. A schematic illustration of robustness and flexibility.
The smaller vertical arrows symbolize stress. Inspired by Husdal (2004)

3.2.2. Robustness

As been described above, one part of the resilience concept denotes strength as in the ability to withstand stress, disturbance and perturbations. As part of the wider resilience narrative, this aspect usually signals the need for maintaining function. Whether the specific function is desirable to maintain or not, a question with political ramifications, the notion of absorbing stress and disturbance could still be of interest to clarify. As already touched upon, *robustness* is one term that encapsulates this notion. As Bruneau et al. elaborate on, robustness is in turn accomplished through one or more means. One mean that enhances robustness, according to Bruneau et al., is *redundancy* – the extent of substitutable solutions in case of disruption or loss of functionality (Bruneau et al., 2003). In other words, redundancy decreases the impact of disruption by providing alternative pathways. In another setting, Levin et al. illustrates the meaning of redundancy as having an extra pilot in the

cockpit that simply enhances the functional redundancy when one pilot is unable to perform for some reason (Levin et al., 2013). As indicated, redundancy can be attended to in different ways depending on what will be made robust. Bruneau et al., focusing on earthquake disasters, apply a wide scope and address redundancy at four interrelated dimensions: technical, organizational, social and economic. In a practical sense such a wide scope incorporates everything from backup systems (technical); alternative sites to operate (organizational); alternative means of providing for community needs (social); excess economic capacity, e.g. suppliers (economic) (Bruneau et al., 2003, p. 746).

Furthermore, Bruneau et al highlights *resourcefulness* as another mean that enhances the overall ability to withstand and absorb stress. This is so because resourcefulness is the "capacity to identify problems, establish priorities, and mobilize resources when conditions exist that threaten to disrupt some element, system, or other unit of analysis" (Bruneau et al., 2003, p. 737). Thus, as a complement to redundancy, resourcefulness encompasses more of an ability to diagnose and recover. In a practical sense, resourcefulness is exemplified by the presence of plans, routines and resources to cope with damage and disruption (Ibid.). In sum, the notion of robustness captures one essential part of striving towards resilience. In consolidating our understanding of robustness, primarily through measures of redundancy and resourcefulness, the concept of resilience is nuances beyond a general notion.

3.2.3. Flexibility

As Dekker et al (2008) & Chelleri (2012) stresses, resilience is all about creating processes that are robust yet flexible. For Dekker et al., flexibility is the "system's ability to restructure itself in response to external changes or pressures" (Ibid., p. 50). In an urban context it reflects on the processes of multiple feedback mechanism which in the end gives rise to an ability to undergo change to cope with changing circumstances. Dekker et al. calls this endeavor "looking out for the potential" (Ibid., p. 57). Without underestimating the challenge of working with previously mentioned resilience-enhancing features, looking for the potential is certainly fraught with more difficulties.

Urban resilience, as touched upon earlier, arguably need to acknowledge the complex interactions between multiple layers of the urban. The question is how to approach something that we knowledge wise, according to Batty et al. (2006), barely scratched the surface of. Where should one, as put forth by Dekker (2008), look for the potential of flexibility? Batty (2012, p. 1) describes how cities evolve: "mainly from the bottom up as the products of millions of individual and group decisions with only occasional top down centralised action". This could be contrasted with Swanstrom (2008) who argues that much

of resilience research fail to appreciate the importance of authorities in both undermining and nurturing resilience. Here we see two perspectives, one highlighting the importance of governance and structures in cities whilst the other points to the complex collective evolution of cities emerging from the ordinary citizen rather than a grand design. These two perspectives are not contradictory to each other however they speak to different points of entry when approaching urban resilience and its dynamics.

Starting on the role of citizens, research points to several aspects where the population lays a foundation for resilience-building in cities, be it in terms of the normative aspects or more concrete resilience matters such as disaster mitigation (Meerow et al., 2016). One field where people for obvious reasons are brought to the front is in the literature on community resilience. Focus here tend to lie on the reactive capacity of communities facing disastrous events, pointing to explanatory factors being for example social capital and social cohesion (Aldrich et.al., 2015). Davis writes about the self-organizing capacities of people in distress:

> *"Within days of the earthquake people began to organize on their own and reclaim the city for themselves by taking over the business of recovery and reconstruction without assistance from government authorities. Their efforts ensured that certain activities were recovered or restored, ranging from housing to medical services" (Davis, 2005, p. 270).*

From this perspective, building resilience as a forced product of top down governance seems implausible. People are the ones who act, innovate and see to their interests (Campanella, 2006). However, this way of viewing resilience as a measure of how well citizens can pull themselves up by the bootstraps is, according to Swanstrom (2008), to narrow a focus on citizens reacting to challenges. Instead, he argues, resilience is in need of a more proactive integrated view: "Resilience in human systems has as much to do with shaping the challenges as responding to them" (p. 17). The structures of the city and its population will, from this perspective, have feedback mechanism dictating the possible ways to prevent and react to stress. For creating flexibility and resilience there is hence a need for these systems to allow for and to strive for these feedback mechanisms to influence the urban processes.

Research on how to govern for building resilient cities is often connected to urban planning and how to expand and enhance local capacities. Spaans & Waterhout (2017) argues that in order to reach resilience on an urban scale one must spur to a sense of common ownership and a joint vision to strive for a resilient city. This ownership is seen to arise from an inclusive approach which allows for feedback mechanism between the urban levels (Desouza 2012). Jabareen (2012) argues that governments should strive towards an: "inclusive

decision making processes in the realm of planning, open dialog, accountability, and collaboration. It is one in which people and local stakeholders, including the private sector, various social groups, communities, civil society and grassroots organizations participate." (Jabareen 2012, p. 123).

Mirfendereski & Corkill (2009) and Adger et al. (2007) argues that governments, to a much larger degree, must allow for flexibility in order to handle the uncertainties facing our cities. Jabareen (2012) argues that flexibility and quickness will prove to be more and more important as our societies becomes more complex and vulnerable.

3.3. Technology and society

As discussed in previous chapters, new challenges with building resilience in smart cities is in large a matter of how cities use and organize around technological artefacts. This chapter is an attempt to propel the understanding of technology and its interaction with society and the individual. Technology here will be examined as a way of bringing forth efficiency and power but also dependency and vulnerability.

3.3.1. The politics of artefacts

The smart city must by default lodge a plethora of technological artefacts that enables the various goals set. Hence, a relevant question is how technology becomes part of the politics of our modern societies. Much research on technology and society argues that we many times perceive of technology as neutral objects/functions and that the common place researchers instead look for politics and power lie in the social and economic systems surrounding it (Winner, 1980; Verbeek, 2014, Feenberg, 2012). According to Winner, this way of approaching technology becomes misleading insofar as it makes us regard of technology to frivolously and hence miss out on important interpretations and explanations of how our societies develop (Winner 1980, 1978). Even though much of the philosophy on technology agrees that technology plays an important role in our modern societies, there is a dividing line regarding the degree of determinism (Feenberg, 2012). Some claim that technology itself is the determining factor for how our societies develop and where social structures comes to adapt and organize itself around various technologies (Feenberg, 2012; Thomas, 1994). The opposite side of this regards of technology as a neutral force where instead the social fabric controls the development of technology through choices made within the dynamics of politics, culture, economics, religion, regulatory mechanisms, etc. (Feenberg, 2012; Thomas, 1994) . Emerging fields has sprung from this attempting to merge the two sides, emphasizing the interconnectedness and evolutionary aspects of technology and the social.

One such attempt is made by Winner who argue that there are choices to be made within societies regarding the implementation of technology but where he also describes how technology for several reasons should be regarded as having politics (Winner, 1980). The key point made is that when approaching technology as something neutral we get ourselves into what Winner (1978) describes as a state of sleepwalking. A state where we primarily look at technology as tools of the present moment which makes us interested in the immediate processes of cause and effect, this in turn makes us poorly equipped to deal with and predict the long-term implications of using specific technologies. Winner continues this line of reasoning pointing out that even though there are many cases where technologies are consciously implemented with ill-natured intentions and against public interest, that is not the main concern. Instead the basic premise is that as times goes by technology develops in both complexity and size which in turn will arrange and delimit our wants and needs. It has become an end in itself (Winner, 1978; 1980).

From this perspective the technology we develop today will take part in constructing a worldview and a reality, influencing our wants and desires in the future. This, he argues, is fast tracked by the fact that the ordinary citizens, at most times, are isolated from the making of any technology which hence means that societal consequences of technologies often are absent and neglected in the production (Winner, 1983).

Similar aspects are touched upon in research on socio-technical systems theory where the general notion lies in the interaction between the users and the producers. Geels (2004) argues, in relation to the development of technical systems, that all infrastructure builds on previous societies and its infrastructure. Hence, planning and implementing new technologies is always done in a social and technological context which in turn develops new forms of path dependency due to a network of reciprocal relationships with buyers, suppliers, and financiers as well as cultural patterns, norms and ideologies (Geels, 2004). This co-evolution of systems also brings with it lock-in effects as time passes, where challenging the current system/order becomes more and more difficult as certain forms of technology and governance solidifies (Geels, 2004). Technological fix is a phrase used to describe a sort of lock-in effect where we have invested and implemented a technological solution which in the end forms the way we frame problems and hence also how we view the various possible solutions (Sarewitz, Nelson, 2008). Maslow's hammer captures this phenomenon: "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail" (Maslow, 1966, p. 15).

These views on technology and its societal consequences of course raises questions as to the normative issues of implementing technology e.g. how involved citizens are in the

early stages of decision-making and implementation of technological solutions. This becomes even more acute today according to Verbeek (2009) and Just & Latzer (2016) who argues that modern technology entails even more potential for producing and reproducing certain behaviors. Verbeek (2009) and Bohn et.al. (2004) refer to this as smart environments, which can "respond intelligently to what we do and that even aim to influence our behavior challenge the basic frameworks we commonly use for understanding the relations and role divisions between human beings and technological artefacts" (Verbeek, 2009, p. 231). Building on big data and algorithms, often prevalent in modern technologies, Just & Latzer (2016) argues that algorithms has become a growing source of social order, shaping our daily lives, our perception of the world and consequently shaping our behaviors.

3.3.2. Climbing up the ladder of technology

This section deals with questions of technological dependency and how this might affect our ability to react and adapt to various stressors. As the title metaphorically suggest, this is a matter of climbing up a ladder of powerful and efficient technology, but where we over time come to discard of previous ladders as we consider them superfluous, primitive, expensive and/or impractical. Continuing the same analogy, we now find ourselves elevated and probably more powerful than ever, the resilience-question following is of course how far we fall in a course of events where our societies lose technological functions we´ve grown used to and dependent on?

Norman uses the term *cognitive artefacts* to understand how we humans interact with technology to enhance our abilities. Many of these cognitive artefacts could serve as to make us stronger and faster, however in the information era the primary focus is to make us smarter, increasing our cognitive capabilities (Norman, 1991; 2014). Problematizing this interrelation between artefacts and human cognition he comes to the conclusion that most times artefacts actually doesn't enhance our capabilities, rather they change the nature of the task (Norman, 1991). Building on this notion of artefacts changing the task, Krakauer (2016) discusses our dependency and the potential risks of creating more powerful technologies managing our daily lives. Krakauer argues that there is need for a distinction between *complementary* and *competitive* cognitive artefacts in times of ever increasingly potent and intelligent technologies being developed (Ibid.). Complementary cognitive artefacts refers to artefacts we humans in some sense can be helped by while also internalizing them. Language and certain forms of information being examples of this when we can make use of it even though the artefacts is removed. The competitive cognitive artefacts instead refers to the opposite where we have changed a task as to make humans superfluous, examples being

GPS, self-driving cars and the mechanical calculator. The digital society with algorithms, big data and artificial intelligence is in large constructed by competitive cognitive artefacts, justifying questions about what would happen in a negative course of events where we potentially lose some, many or all artefacts.

As touched upon in the smart city chapter, Kitchin and Dodge introduce a related problem with the concept of code-space, which is a way to describe the relation between artefacts and space. Code/space is when "software and the spatiality of everyday life become mutually constituted, that is, produced through one another. Here, spatiality is the product of code, and the code exists primarily in order to produce a particular spatiality" (Kitchin & Dodge, 2011, p. 16-17). Two easy-to-grasp examples are check-in areas at airports and computerized cash registers at supermarkets. When software crashes, space (check-in area and supermarket) doesn't function because the code/space are so interdependent. A city will, if the ideal is materialized, be a code-space at an urban scale. The fundamental questions is then (if we don't just exit this journey all together) how do we handle crashes? What do we do when code/space pauses?

3.3.3. Human centered technology

As described in the two sections above, technology brings with it great challenges. However, there are also the obvious upsides to technology. The questions become how one can mitigate the downsides and propel the upsides. As Winner (1978) argues, one aspect is simply to acknowledge to potent nature of technology when it comes to how it transforms our societies over time. Bringing these often abstract questions to a more concrete level is according to Lin (2013) necessary, especially when the technology is becoming increasingly more powerful. Lin discusses two approaches: constructive technology assessment (CTA) and Participatory technology assessment (PTA). Much like Winner, Lin argues that innovations are often developed in private laboratories with little to none public scrutiny. These approaches are hence meant to include more actors and more perspectives into technologies already in the production and implementation faces, in contrast to the most common after-the-fact assessment (Lin, 2013).

CTA aims to influence technology design itself by promoting interaction among stakeholders throughout a technology´s development process. Stakeholders should, according to Lin (2013), be broadly defined to include: technology developers, regulators, workers, end users, and the potentially affected public. Inviting this heterogeneity into the process is hoped to generate more widely accepted outcomes and fewer negative effects. Lin (2013) continues to describe how CTA can be used to identify risks and consequences of a

certain technology however if one is to pursue normative goals and involve citizens and other societal actors a more proper approach is the so called PTA. This strategy is more concerned with learning, evaluating and designing together with citizens (Ibid.).

4.0. Results (Part I)
Building an analytical framework

The aim of this chapter is to understand how a framework of resilience can be applied to the smart city. In general, we refer to resilience as the ability of the urban system to absorb shocks and perturbations as well as to reorganize while undergoing change. It is within the existing urban system that the ideal of the smart city intervenes. Supported by our understanding of the smart city, this intervention is primarily expressed through embedding the urban system with ICT-networks and smart technology. As has been discussed, while this intervention entails promising possibilities, it brings several challenges to the fore. These challenges are, as we will discuss, intelligible as challenges of building urban resilience. By combining insights from the theoretical framework and interviews with generalists, the task of the remainder of this chapter is to create a framework that encapsulates these challenges. A guiding principle is that these challenges pertains to building a robust yet flexible resilient smart city. Accordingly, this is how the following discussion is presented: firstly, challenges of building robustness, secondly, challenges of allowing for different degrees of flexibility.

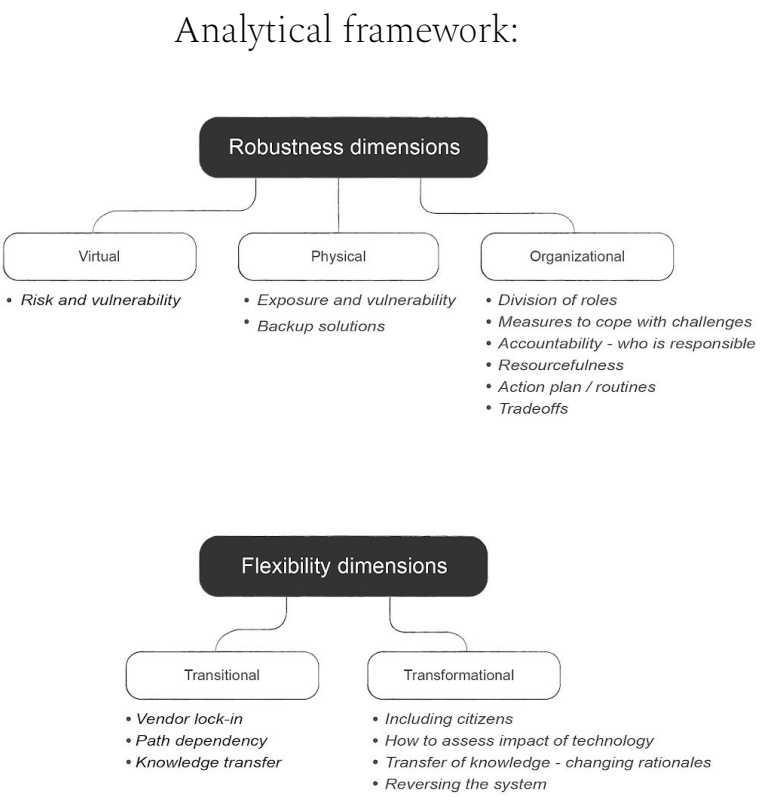

Fig. 4. Overview of the analytical framework that illustrates how a resilience framework can be applied to smart cities.

4.1. Building robustness in the smart city

Building on previous theoretical input, *robustness* is deemed as an overarching end of resilience (Bruneau et al., 2003; Dekker et al., 2008; Levin et al., 2012). Adapting Bruneau et al (2003) to urban resilience, robustness is understood as the strength or ability of the urban system to withstand stress without loss of function. In the smart city, the functions of the urban system is, to a greater extent than before, integrated with ICT-networks and enable by smart technology. It is as the "old city of concrete, glass and steel now conceals a vast underworld of computers and software" (Townsend, 2013, p. xii). What follows this gradual shift, towards an urban system that is evermore intermingled with complex networks of modern technologies, seems to be an increased dependency on technology to function as intended. Accordingly, as part of building resilient smart cities, attention need to be direction to perturbations and disturbances that could challenge the ability of such technologies to maintain function. Although not easily separated and certainly interrelated with each other, we argue that such challenges reside in a virtual, physical and organizational dimension of the smart city. In the following, we elaborate on what these dimensions contain.

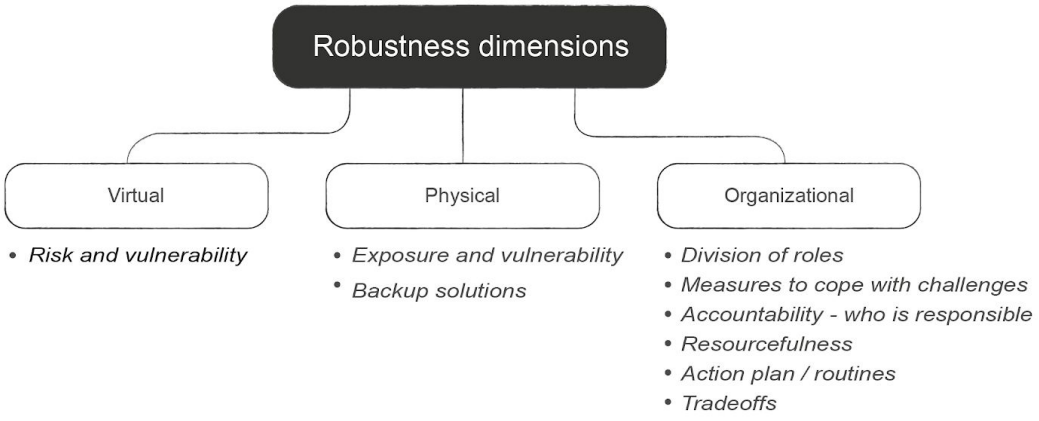

Fig. 5. Robustness dimensions and identified challenges from the analytical framework (see fig. 4)

Virtual dimension

Central to the smart city is the idea of instrumenting and interconnecting the built environment and citizens with the help of modern technology. The process of becoming smart often involves the diffusion of numerous sensors that, interconnect with each other through wireless sensor networks, build on and feed into other ICT-systems (Picon; 2015; Pierce & Andersson, 2017). As much as this idea brings forth fascinating and novel ways of

imagining, planning and managing the city it also raises burning questions in regard to risks and vulnerabilities. Primarily, risks and vulnerabilities stem from the fact that the smart city propel the conflation of modern technology and the urban system, and in so doing increases the dependency on such technologies to function as intended. Although the condition, that modern societies are becoming more dependent on ICT that in turn can be the subject of various forms of disruptions, is not an entirely novel one, it's arguably heightened by the development of smart cities (Asplund & Nadjm-Tehrani, 2016; Staudemeyer et al., 2017; M. Colding, personal communication, 24 nov. 2017). Detailed earlier, various forms of risks and vulnerabilities relate to the proper functioning of modern technologies. Central here is software technology as buggy and brittle prone to, for example, malicious attacks (e.g. viruses) or originally poorly programmed (e.g. bugs and glitches) (Ronen & Shamir, 2016; Asplund & Nadjm-Tehrani, 2016; M. Colding, personal communication, 24 nov. 2017). As Ronen & Shamir detail in regards smart city devices, malicious attacks are not necessarily limited to killing the intended functionality completely. If the smart lamppost is the case, functionality can also be misused (e.g. lights are turned on when not wished for); extended (e.g. lights are used in an completely different and unexpected way); as well as ignored (e.g. the sensors in the lamppost are used as the best attack vector for accessing other components in the same network) (Ronen & Shamir, 2016). Further adapting Bruneau et al.'s (2003) definition of robustness to the smart city context, the ability of software technology to withstand stress without loss or unwanted corruption of function can be understood as one central aspect of challenges building resilience in the smart city.

- *Risks and vulnerabilities*

Physical dimension

The virtual dimension of the smart city is undoubtedly dependent on a physical dimension. This physical dimension encompasses all those physical objects and structures that contain and enable software technology to function. Amongst many things, this could be the hardware of sensors, nodes and hubs down to optical fiber cables in the ground that all together permit the successful communicate of data through a network (M. Colding, personal communication, 24 nov. 2017). To some extent, it follows that the challenge of robustness resides in whether such physical components are exposed and more or less easy to outmaneuver. Obviously, the degree of dependency, where several services depends on one or few others, is a matter of significance. As today, the most tangible case is probably the dependency on electricity as "the lifeblood of smart cities" (Townsend, 2013, p. 35). Here,

reflecting on redundancy, i.e. the ability to use some sort of backup or alternative pathway when something fails, is one step towards coping with challenges of robustness (Bruneau et al., 2003). Thus, the challenges of building robustness in the physical dimension of the smart city pertains to the following themes:

- *Exposure and vulnerability*
- *Backup solutions*

Organizational dimension

Intertwined with the virtual and physical dimensions of the smart city is the organizational dimension. Broadly, the organizational dimension can be conceived of as a governance network with state and municipal actors, industry, and non-state actors etc. (Meerow et al., 2016). However, when it comes to previously identified challenges, it seems reasonable to center on the municipal organization, i.e. the governmental body responsible for the administrative area where smart city initiatives take place, and their relation to the ICT-industry, i.e. actors that provide most of the smart technology and the technical know-how thereof. Whether within one of the aforementioned actors or in their collaboration with each other, it's arguably people who decide on and act upon measures that are put in place in order to cope with challenges of virtual as well as physical character. In the virtual dimension, the measures one take to enhance the ability of software technology to withstand stress are usually captured in the term cyber security (M. Colding, personal communication, 24 nov. 2017). Here, the awareness of risks and the need for protection is a prerequisite (Asplund & Nadjm-Tehrani, 2016). Amongst many things, security measures can entail designing a system with redundancy that duplicates a component so that if it fails there will be a backup (Staudemeyer et al., 2017; M. Colding, personal communication, 24 nov. 2017). As a resilience enhancing feature, redundancy can also be extended to the physical dimension.

In general, the organization that need to cope with challenges may do so more properly if it is resourcefulness. This is so, as discussed earlier, because resourcefulness has been identified as a feature of enhancing resilience in that it captures the capacity amongst people to identify problems, establish priorities and mobilize resource to diagnose and cope with challenges (Bruneau et al., 2003). More concretely, this could be express in a division of responsibilities that, together with plans and routines, guide the effort of recovering that which was disrupted. As a prerequisite for resourcefulness, in circumstance of disruption, when one or more smart city functions may be damaged in either virtual or physical sense,

the general issue is who has the responsibility for what. Additionally, depending on how critical the function is, solutions for providing partial service may be needed in the meantime (Staudemeyer et al., 2017). Finally, it's worth recalling that measures for reducing and coping with challenges unfolds in a context where other goals are perceived as significant (e.g. efficiency and cost control), always subjected to the constraints of available resources (e.g. time, money) (Dekker et.al., 2008). Thus, there will be several trade-offs between different goals. To provide an example, in the case of sensors and other small smart devices, as Tragos et.al. points out, strong security is potentially a conflicting requirement to how fast the device can perform its function (Tragos et al., 2017). In sum, the challenge of building robustness in the organizational dimension, i.e. the organization that upholds and acts upon challenges in the virtual and physical dimension, is captured in the following themes:

- *Division of roles*
- *Measures to cope with challenges*
- *Accountability - who is responsible*
- *Resourcefulness*
- *Action plan / routines*
- *Tradeoffs*

4.2. Flexibility

Resilience, as mentioned before, is perceived of as being the outcome of systems that are robust yet flexible. As previously touched upon, while robustness denotes the strength of the urban system to withstand stress, flexibility denotes the ability to change and adapt (Dekker et al., 2008). Furthermore, the notion of flexibility can be interpreted as containing a spectrum of change, from the small and incremental to the more profound. Inspired by Chelleri et al. (2012), we call the lower degree of change *transitional* and the higher degree of change *transformational*. As discussed in the previous section, flexibility much like robustness is an ability that resides amongst people and their interaction with each other. In the smart city, as we detailed earlier, the municipality and the ICT-industry are key actors. In addition, the smart city is not smart without technology and not a city without its citizens. Accordingly, we argue that challenges of maintaining different degrees of flexibility stem from the interrelationship between these actors in the smart city on the one hand, and the role that the smart city assign to modern technology as an inseparable part of the urban way of life on the other hand.

In general, resilience research point to the importance of the local urban context and, whether emphasis lies on the role of citizen or governments, that governing such context should strive for an inclusive approach which allows for crucial feedback mechanisms opening up for processes enabling resilience (Jabareen, 2012; Meerow et al., 2016). More precisely, how such governing can maintain an ability to adapt and change is harder to prescribe. However, to recall Geels (2004), that which might hamper that ability is how relationships between actors in the city – e.g. suppliers, buyers, financiers – form bonds solidifying over time. This results in a so called path dependency and lock-in effects as certain ways of organizing around problems and solutions becomes favored to others (Geels, 2004). Such solidified constellations of actors, as Geels (2004) touches upon, are difficult to change and challenge. This could become an issue with regards to flexibility and ability to internalize and materialize new feedback from new political views or input from citizens.

Of course, this is common in all modern societies, however, smart cities and the high-tech/digital solutions required, speaks to some aspects being accentuated. Here, the intensive use of ICT and computational techniques to process and analyze data are, according to several scholars, determining factors of what kind of interrelationships and ways of framing and organizing around problems that the smart city accentuate (Verbeek, 2014; Gabrys, 2014; Rabari & Storper, 2015). Algorithms, as an example of a technique of processing and making data intelligible, are not only helpful tools for solving many urban problems but also, to some extent, framing how that problems is perceive and affecting the scope of proper solutions (Klauser et al., 2014; Rabari & Storper, 2015). This could be compared to Höjers experience of the smart city development in general, arguing that smart cities often are a depoliticized matter, resulting in them being developed with a lot of momentum but with little direction (Höjer, personal communication, 24 nov. 2017).

Along the same lines, Winner (1978) and Lin (2013) discusses the difficulty of assessing and evaluating the impact of technology. Further they also point out that societal values and various side-effects often times are, intentionally or unintentionally, neglected in the closed environments where technologies are produced. In the following, we specify further what challenges the smart city may poses in terms of maintaining transitional as well as transformational flexibility.

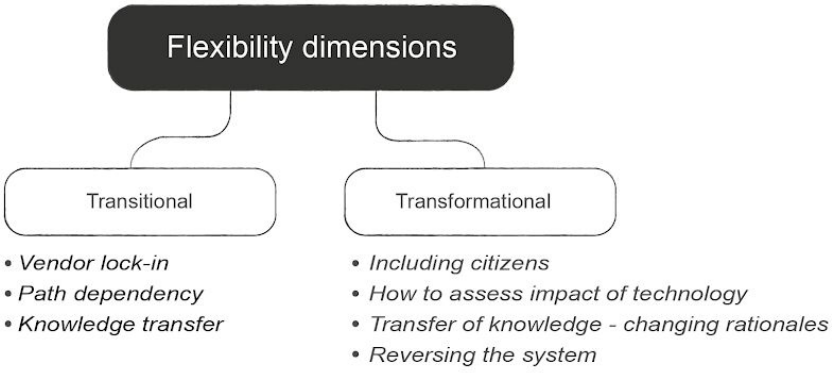

Fig. 6. Flexibility dimensions and identified challenges from the analytical framework (see fig. 4)

Transitional flexibility

The role that different key actors play in the smart city might be an angle of approaching the ability to change and reorganize in the more immediate. As discussed previously, the ICT-industry is one such key actor that purposely drives the development of smart cities. First and foremost, the ICT-industry holds this position because it provides the city with that which lies at the heart of becoming smart: hard- and software technology and the know-how thereof (Townsend, 2013; Kramers, personal communication, nov. 23, 2017). Another key actor is the municipality that often strategically decide on and coordinate the implementation of smart city solutions within its administrative area (Pierce & Andersson, 2017). The concern is that the ICT-industry, qua provider of many technical solutions of the smart city, might strive for all-encompassing solutions. This becomes accentuated by the fact that smart city initiatives often times requires highly complicated and custom made technological solutions which, Kramers argues, often few companies can provide. Kramers goes on to argue that this is even more accentuated by the fact that, as she said, "the starting field has already gone" (Kramers, personal communication, nov. 23, 2017). Although such all-encompassing solutions might seem favorable in some aspects, both to the vendor and the purchaser, it signals the risk of vendor lock-ins, i.e. depending on one developmental path that cannot easily be undone or diverted (Kitchin, 2015). Such situations seem to impede the ability to change and reorganize. Thus, vendor lock-ins is potentially a challenge for striving for a resilient smart city that is both robust yet flexible.

It is not, however, only direct lock-in situations that dictate the outcome of certain choices. Geels (2004) talks about an emergence of path dependency through habits, norms and ideologies that forms over time. Magnus Colding (personal communication, 24 nov.

2017) confirms this by noting that organizations oftentimes have interests in maintaining status quo, even though they in theory can change, because changing requires time, money and knowledge. Hence, challenges for creating a flexible smart city may lie in the lock-in situations formed through the technical solutions (virtual & physical) or in the path dependency developed over time in the interplay between different actors.

One such aspect connected to the relation between enterprise and municipality regards knowledge and capacity. As discussed above, the efficiency promised by smart city solutions many times relies on: physical components, complex algorithms being developed as well as data being stored, gathered and interpreted. The question is what consequences this has on the ability to effectively govern for flexibility, if more and more processes and knowledge is transferred from the public sphere to the private sphere.

- *Vendor lock-in*
- *Path dependency*
- *Knowledge transfer*

Transformational flexibility

Where the section above on transitional flexibility primarily address matters from interactions within the various smart city initiatives, this section instead is intended to explore flexibility matters from a wider societal perspective. Path dependency and lock-in effects are still highly relevant concepts, however when approaching a wider framing of the urban fabric these concepts becomes too vague and could refer to almost anything. Here instead these terms are captured through more narrow themes that reflects the urban dynamics. Some flexibility aspects of this section deals with the developmental phases of the smart city, while others refers to later phases where flexibility describes the ability to change or reverse an already implemented system and also how societies can be flexible enough to handle potential breakdowns of certain smart city functions.

Citizens has in this study been described as important in the pursuit of resilience, this for both normative- and concrete reasons. These two often interlink in the resilience literature, where resilience is perceived of as the outcome of complex processes of both components and actors (Desouza & Flanery, 2013). In the case of smart cities, flexibility matters must hence be considered both in order to adapt to democratic desires as well as allowing for important feedback mechanisms between citizens, technology, institutions and enterprises. This in order to create processes that allows for an effective pursuit of a resilient city. Here governance is described to play a role in anchoring resilience questions at the

various urban levels by making it into an inclusive endeavor. After all smart cities are going to be implemented into an urban fabric with pre-existing values, norms, habits, etc. The question is how to include citizens in the development of smart cities?

Technology as argued in this study, is not a neutral matter, rather it comes with inherent politics, potentially challenging the ways we organize and behave (Feenberg 2012, Winner 1980). Lin (2013) here propose that technology hence should be assessed as such, where different considerations should be brought into the developmental phases of technologies and the smart city solution. This becomes even more accentuated in smart cities for several reasons. Firstly, due to the fact that much of the envisioned smart city technologies are seen to be more potent than previous technologies in that it can be made to actively produce and reproduce certain behaviors. Secondly because this technology is going to merge with something as complex and political as a city. The question here is how to assess the impacts of technology both short and long-term.

This connects to the reversibility of smart city functions. The concepts of competitive cognitive artefacts (Krakauer 2016) and code/space (Kitchin & Dodge 2011) were here used to approach questions of how we build more of our urban environments based on high-tech functions which in a sense competes with citizens in that they make us change our behaviors and adapt to the new technological solutions. On a shorter time frame, there is a question raised here if this creates lock-in situations where we adapt to and change our behaviors to fit a certain smart environment which then becomes very hard to challenge. Challenging these potent urban smart environments might from this perspective become more and more difficult over time and hence potentially reduce flexibility. The other issue connected to this reflects on how these competitive environments and technologies might over time come to change our reactive capacity to a potential breakdown of smart city functions. As previously described, there are potentially many challenges with building robust smart cities. Or as Townsend (2013) points out, the smart city in lack of electricity could end up in an almost complete stand still. What happens to the smart environments then? How can citizens and institutions be flexible in such a situation? It seems as if though these questions will become more and more relevant over time as technologies take over citizen's functions in everything from driving cars, to for example making the predictions consulting the urban planning departments. This is of course common already in our societies, the question is if smart cities propel these risks and how this potentially could be solved.

The final matter reflecting back on previous points is a general question of flexibility in terms framing and solving problems. The term technological fix where addressed as phenomenon occurring in modern societies where a once implemented technological

solution results in a path dependency where it is difficult to look in new directions in order to solve problems. Geels (2004) refers to this path dependency as a result of complex interactions shaping new rationales through the creation of, among other things, new norms, ideologies and cultural patterns. The question is how to ensure flexibility and openness in such as technologically centered ideal as the smart city?

The various flexibility issues raised above is reduced into following themes:

- *Including citizens*
- *How to assess impact of technology?*
- *Transfer of knowledge - changing rationales*
- *Reversing the system*

5.0. Results (Part II)
Applying analytical framework to a Swedish context

In this chapter we present and elaborate on results from the interviews with the chosen Swedish smart city initiatives: City of Stockholm, Municipality of Lund and Municipality of Helsingborg. Additionally, the experience from the Swedish smart city initiatives are complemented with the results from interviews with an international outlook, namely one representative from the city of Eindhoven and one from the city of Oulu. To this international outlook we add a national point of reference with an interviewee from the Swedish Civil Contingencies Agency (MSB). After an introduction to what the Swedish smart city initiatives comprise, the results from the interviews are structured in accordance with themes that emerged in our analytical framework.

The purpose of investigating smart city initiatives, complemented by an international as well as a national outlook, is to substantiate our analytical framework with experience in practice. Later on, this approach opens up the possibility of refining the analytical framework and more thoroughly discuss what challenges that are most pertinent in building resilient smart cities from both a theoretical and a practical perspective.

Introduction to smart city initiatives

City of Stockholm

The city of Stockholm aspires to be the world's smartest city by 2040 (Stockholm stad, 2017a). Allegedly, in the world's smartest city, life for those who live, visit and work in the city will become easier and better (Stockholm stad, 2017b). Stockholm is the only smart city initiative to have adopted a strategy, available as a public document, that aims to guide the effort to fulfill this aspiration (Stockholm stad, 2017b). Herein, enabling factors that make the smart city possible are connectivity and open data, integrated platforms, sensors and other technologies. These technical features are guided by seven strategic principles and eight principles of implementation (Ibid.). As for now, the city of Stockholm target three so called prioritized operations: smart lighting, smart traffic control and smart locks. These three projects are centrally funded and identified to kick-start the implementation of the smart city strategy (J. Palm, personal communication, 18 jan. 2018). Identified as being able to kick-start the smart city strategy means that the projects have good feasibility, are long-term

and scalable, and provide great benefit and impact on one or more target groups such as citizens, tourists and business people (Stockholm stad, 2017b).

Municipality of Lund

In the municipality of Lund, the innovation platform Future by Lund is the organization that most clearly advocates the development of smart cities. Future by Lund is co-funded by the municipality and three national Swedish agencies (Future by Lund, u.d.). Future by Lund have several areas of interest and brings together a wide range of partners from the public and private sector as well as academia. As a prerequisite for becoming smart, Future by Lund has, together with the Faculty of Engineering at Lund University and the private company Sensitive, installed a wireless sensor network. On top of this wireless sensor network runs several smart city projects. One of these projects are "Smart public space" in which city utilities and functions, instrumented with sensors that communicate via the wireless sensors network, are supposed to improve and innovate the way the city is managed. Amongst many things, this entails the deployment of sensors in order to monitor electric switchboards, gather data on how bicyclist behave in traffic and communicate when waste bins are ready to be emptied (Ibid.).

Municipality of Helsingborg

In the city of Helsingborg, the municipality of Helsingborg and the municipal owned energy company Öresundkraft have worked together in creating the so-called City hub. The City hub consists of a wireless sensor network that permits the transmission of information by numerous sensors to a common platform. In time, it is assumed, when all kinds of information from sensors deployed in the city starts to feed into this platform, innovative solutions and service will start to emerge. This is the next step towards becoming the smart city of Helsingborg (Öresundskraft, u.d.). Apart from this, several pilot projects such as keeping track of lifebuoys along the beaches of Helsingborg with the help of sensors and smart waste bins, much like in the municipality of Lund, are up and running (A. Hall, personal communication, 20 dec. 2017).

Why smart cities?

At the heart of the conception of the smart city, as a common denominator for the Swedish smart city initiatives, lies the use of modern technologies to spur innovative and more effective ways to tackle urban problems. More precisely what these urban problems comprise differs from city to city as well as from interviewee to interviewee. In general, the scope of

possible benefits in advancing this conception of the smart city is wide in that they range from management and maintenance aspects in public space to the city's climate targets. The way in which the smart city ideal materializes in practice is mainly through the deployment of smart devices (e.g. sensors, actuators, hubs and nodes) interconnected with each other through ICT-networks. Finally, some kind of common platform, enabling the display and utilization of data gathered by smart devices, is part of the implementation of the smart city in practice. In regard to the relationship between the public and private sector, all interviewees acknowledge that the private sector will develop and provide the hard- and software technology that facilitate the implementation of the smart city.

5.1. Robustness

As presented earlier, the smart city can be understood as an urban development ideal that intervenes into an existing urban system. As we've discussed, this intervention is characterized by instrumenting the physical urban fabric with sensors and other smart devices that, by communicating through different networks, feed data into platforms. Although in a small scale, as the introductions to the smart city initiatives detail, this understanding corresponds with how the smart city is implemented in practice. On the basis of our analytical framework, we contend that the development of smart cities accentuates several challenges in terms of the ability of the urban system to withstand stress without loss or unwanted corruption of function – what we call challenges for building robustness. In the following section, we present the results from interviews with practitioners reflecting on these challenges.

Virtual dimensions:

- *Risks and vulnerabilities*

There is a general agreement amongst the interviewees, from Stockholm and Helsingborg to Lund, that the smart city introduces risks and vulnerabilities in regard to the proper functioning of smart devices and ICT-networks. As Hall, an engineer at municipality of Helsingborg, puts it:

> *"I do not want our lampposts to be included in the US presidential election /.../." - Hall*

Lahti, the project manager for the smart city initiative in the municipality of Helsingborg, elaborates on the topic of risks and vulnerabilities by highlighting how sensors, a concomitant part of implementing the smart city, are developed and advertised:

> *"Today, it comes down to the fact that they are small, simple and battery-powered which is convenient because one doesn't have to check up on them." - Lahti*

As Lahti adds, these sought-after requirements may impinge on risks and vulnerabilities in so far as they come at the expense of keeping security up to date. Hall reflects on the long-term effects of such a scenario:

> *If you have a device that doesn't allow for security updates […], it follows that those sensors that are installed today, which are not protected from intrusion or can be hacked, that's a problem that we might have to live with for ten years - Hall*

In addition, Trana, an official representing the smart city initiative in the municipality of Lund, reflects on risks and vulnerabilities in regard to the complexity of interconnected system components (e.g. different sensor networks communicating with a common platform) and the multitude of actors that will work on and utilize them. In such situation, Trana argues:

> *"There will be many layers that should be reliable and resistant to external impact" - Trana*

Physical dimension:

- *Exposure and vulnerability*
- *Back-up solutions*

Challenges of building robustness in the physical dimension, as we previously discussed, encompass several issues. Some issues are more general challenges to all smart city initiatives, as in the dependency on electrical supply in order for the smart city´s digital system to function as intended. In the circumstances of power outage, as Lathi wonders, "how will society work then?". In response, several interviewees advocate for redundancy, i.e. a backup solution.

Although electricity is the lifeblood of the smart city, the perpetual flow of data is arguably a necessary part of becoming smart. It follows that the challenge is whether the successful transmission of data is dependent on certain nodes and hubs that in turn are exposed and vulnerable. In the sensors network in the municipality of Helsingborg, such

nodes of communication are called Gateways. In response to how exposed and more or less easy outmaneuvered these Gateways are, Martinsson says:

> *"They are very hard to access since they are located high up within very closed areas"*
> *- Martinsson*

In response to the same question, Trana argues that one can work with a less hierarchical structure where the dependency on one or few nodes are reduced. Consequently, as Trana puts it, a preferred implementation is:

> "*a system with no single point of failure" - Trana*

However, as he goes on to point out, their smart city initiative is aimed at creating platforms and data storage solutions that many actors could partake in. Hence, such solutions may become increasingly important for the proper operation of many actors and needs to be safeguarded.

Organizational dimension:

- *Awareness of risk and vulnerability*
- *Tradeoffs*
- *Division of roles*
- *Accountability - who is responsible*
- *Action plan / routines*

In the end, it is people who are aware of risks and vulnerabilities that the smart city introduces and decide on and carry out measures to handle them. Consequently, how people organize around smart city solutions may open up to a more nuanced understanding of what challenges that building robustness entails. In general, most interviewees are convinced that the smart city entails an increased collaboration between the public and the private sectors. As Kisch, the project manager for the smart city initiative in the municipality of Lund, argues:

> *"This will be a question as to how the public and private will work together […] I don't think the municipality will develop their own system, rather the municipality will purchase existing system. It's too costly to develop and maintain these systems." - Kisch*

As Kisch suspects, which has been elaborated on previously, most of the technical solutions of the smart city may be developed by the ICT-industry. Consequently, most interviewees perceive the municipality they represent as purchasers. In these conditions, as most of our interviewees argue, risk and vulnerabilities can be prevented by having procurement competence. In other words, each and every municipal department need to have an understanding of what risks and vulnerabilities that follow from implementing certain smart city solutions and demand proper measures to handle them. Some suggestions are made as to what proper measures comprise. For example, as the smart city develops, technical solutions are going to be interconnected and implemented on a large-scale intermingling with evermore aspects of everyday life in the city, Palm, an IT-architect at the city of Stockholm, argues that:

> *"We must have redundancy from the beginning and always have a manual process in the background. It must be so because it is about people's lives, which is not always the case in the industry.*
>
> *For example, we cannot have a traffic system where everything goes through a central platform without back-up. There, maybe you can have different levels where the first one is based on 5G, the other goes through another platform and a third where everything is getting yellow and one last option to call out traffic guards" - Palm*

However, as most interviewees stress, procurement competence is all about navigating through trade-offs. Redundancy, for example, is generally desirable but may not always be necessary and certainly not always feasible in terms of available resources. Thus, as Palm adds, the measure one take to cope with challenges relates to how critical the function is from a societal perspective. In the same vein, Martinsson, attending to the smart city development on behalf of the municipal owned energy company in Helsingborg, suggest that risks and vulnerabilities in the smart city should be cast in the light of a distinction between "nice to have" and "need to have" functions. In general, functions that are "nice to have" requires less security and can be connected to the Internet while functions that are "need to have" requires another set of security measures. As Martinsson puts it:

> *"This means we see that the sensors we set up, some will shoot straight up in the Internet. Some will be on a network server in one of our operator hotels or redundant to run locally in the situation when the Internet is not available." - Martinsson*

In general, the balancing act between proper measures to handle risks and vulnerabilities, in a constant tradeoff between other goals, leads to a, our interviewees suggest, greater need for competence within municipal departments. In some respects, as Palm see it, some demands

can be quite independent of the specific municipal departments and worked out in guidelines on a national level. However, this is not an easy task:

> *"There are such initiatives but […] they do not keep pace with the development and implementation of smart city solutions" - Palm*

Furthermore, while the interviewees stress the need for procurement competence, there is also an agreement amongst all our interviewees on the importance of being prepared for circumstances of disruption, be it in a virtual and/or physical sense. As Hall and Lahti reflects on the issue:

> *"If we only have one transmitter and it goes down, what happens then? Is the smart city suddenly dumber?" - Hall*

> *"One has to assess the risk and, if something happens, have a plan for what we then do" - Lahti*

On the other hand, at least in regard to their respective smart city initiative, none of our interviewees had any such actually existing plans or guidelines that could be referred to. The reason why they lack such actual preparedness, some interviewees argued, is because their smart city solutions target less critical city functions and that the need for preparedness to handle malfunction is less urgent. Others said that they are about to adopt plans and guidelines together with upcoming projects. The same discrepancy in answers extends to the actual attention that is reserved for working with risks and vulnerabilities in general. Consequently, some interviewees argue that their smart city initiative is small-scale and in a conceptual phase. In these circumstance, where one tries to foster an innovative and experimental milieu, questions relating to how one cope with potential risks and vulnerabilities are perceived as something that will be develop later. Other interviewees, on the contrary, argues that such issues need to be an integrated part of the smart city initiative from the very beginning.

Robustness - Outlook & Analysis

There seems to be a consensus among our interviewees that the smart city brings forth new challenges in terms of building robustness. In theory, however, most of our interviewees seem fairly confident that one can remedy such challenges by, for example, implementing secure systems with redundancy and few or no single point of failures. Whether such confidence is justified or not is difficult to answer. In general, as both Martinsson and Palm concludes, keeping pace with all possible threats is an impossible task. Önne, working with

cyber security issues at the Swedish Civil Contingencies Agency, testify to this complex and evolving situation of threats and adds that generally in Sweden, from his experience, the dependency on ICT is increasing while efforts of security measures aimed at handling potential threats lag behind.

As we outlined earlier in this study, in the process of becoming smart, even the apparently harmless lamp post can be the subject of several threats (Ronen & Shamir, 2016). Thus, part of the challenge in building robustness seem to relate to the complexity of understanding *where* threats are coming from. Several interviewees stress the need for backup solutions, however as Ronen & Shamir points out, one also have to deal with more than just breakdown. Apart from the risk of reducing functionality, smart cities, in bridge the physical and virtual world, opens up to threats aimed at misusing and extending functionality as well as exploiting smart devices as a way to damage other functions (Ronen & Shamir 2016).

Furthermore, accompanied by an understanding of where threats are introduced are questions of *what* to do about them and *when*. Since the ICT-industry provides most of the technical solutions of the smart city, as both previous research and our interviewees contend, the answer to these questions are partially worked out by the municipality in the process of purchasing smart city solutions. It follows that such a task, referred to as procurement competence, seem to be of great importance for building robustness in practice. In representing an international outlook, Onland and Rantakokko testify to the importance of procurement competence but adds that such issues are not sufficiently catered to at the municipal level. One reason, Onland argues, is that solving these issues has often proven difficult, partially due to the fact that there are so many vendors and actors in the smart city which makes a coordination of these questions difficult. This, he argues, also reflects upon the difficulty of anticipating the upscaling effects of threats as smart cities continues to develop.

In practice, the importance one can assign to procurement competence and other robustness enhancing measures is arguably a balancing act between other goals, always subjected to the constraints of available resources. In regard to the balancing act between different goals, as a shared sentiment amongst some interviewees, there is a perceived conflict between experimenting with and promoting benefits of smart city solutions on the one hand, and attending to risk, vulnerabilities and strategies to cope with them on the other hand. In stark contrast, Önne argues that assessing risks and vulnerabilities of becoming smart, no matter how harmless one assumes the functionality to be, is something that needs to be part of the process from the beginning. To leave such questions for later consideration

is unwise since it's hard to sprinkle on security measures afterwards when the project has its own momentum. Along the same lines, Tragos et al. state, "post-mortem corrections and improvements can only cover some holes" (Tragos et al., 2017, p. 64). Thus, if such a goal conflict prevails among organizations that implement smart city solutions it may amount to a significant challenge for building robustness.

Moreover, the fact that any organization is constrained by available resources may lead to a likely scenario, which can be conceived of at multiple scales, in which cities with appropriate amount of resources has greater opportunity to enforce a smart and robust city while, in a context where such resource are scarce, the city might be smart but perhaps frightfully vulnerable.

5.1.2. Flexibility - Transitional

Much of this dimension builds on the previous dimensions of robustness which gives an overall picture of how the municipalities organize their smart city initiatives as well as how they reason and address questions of vulnerability and risk. Here we raise questions of flexibility that are associated with how the municipalities chooses to organize their smart city initiatives. Following themes identified in analytical framework (Part I):

- Vendor lock-in
- Path dependency
- Knowledge transfer

As previously discussed in this chapter, several of our interviewees argues that smart cities will become a matter of finding satisfactory cooperation between the private and the public. In the case of smart cities, the private sector is described as necessary due to the knowledge intensive competence required for materializing the various smart city initiatives. Approached with questions regarding the risks of vendor lock-ins, most of our interviewees argues that this is one of the biggest challenges they face connected to a broad range of issues when developing their smart city initiatives.

One such issue lies in the technological domain where all of our interviewees in one way or another discusses the need to strive for so called *open standards,* which is meant to allow a variety of actors to communicate through and connect to common platforms. This in contrast to closed or specific standards where each and every vendor uses their own systems. Landahl refers to open standards as a harmonization of the systems and argues that this will

be a big part of procurements in the upcoming years, but where he reflects on potentially diverging future scenarios. Firstly, he concludes that it has been proven difficult to get vendors to work towards open standards because they want to keep out potential competitors and get a larger piece of the market for themselves. This, he argues, will likely remain a problem ahead.

> *"Oftentimes there is no harmonization, only our lamp posts have four different standards."*
> *- Landahl*

He goes on to argue that a smart city potentially will consist of thousands of vendors and thousands of functions which might give an indication to the challenge of harmonization. However, he wonders, one possible scenario is that municipalities may become better at demanding this which in the end could result in vendors themselves striving for this by their own accord.

According to some of our interviewees, not succeeding with this would in a sense be contradictory to the smart city, who envision their smart cities as a rather open and dynamic system where many smaller and larger companies can develop their business models through innovation and competition. According to Hall and Lahti from Helsingborg and Palm from Stockholm, aspects of path dependency and lock-in effects could potentially be mitigated if one chooses to work with many different actors/vendors, even though this in some sense may prove less straightforward. Palm claims that this way of diversifying smart city initiatives may prove to be a great strength both in terms of reducing vulnerability but also in order to avoid too much dependency on too few actors. According to Palm, a situation where there is a lack of competition or where one vendor becomes very efficient could prove to be challenging. She further argues that this might lead to a potential path dependency when a collaboration has developed over long time and hence, due to the knowledge intensive character of smart cities, always becomes the favored candidate in a procurement. Lahti, much like Landahl and Palm, discusses how we might end up with a few really good actors who potentially could take over the market and hence have more possibilities to lock-in municipalities, which many vendors aims to do. However, he also describes that this is not the only strategy out there:

> *"I have met with companies that think differently: 'We will offer this part, the module, the feature, so damn good that we will still be on the market even though we do not lock the customer to us with closed standards.'" - Lahti*

Another aspect that related to this is how municipalities can maintain the knowledge and capacity to govern the city effectively as more and more functions ends up in the private sector, such as storing data, gathering data, interpreting data, as well as developing algorithms. Hall argues that this in some sense is a double-edged sword, where one must balance the efficiency of the smart city with an ability to place demands on private actors:

> *"We want to release as much data as possible as open data. Only when we do, we become smart. Then others can use our open data and create services and applications of it." - Hall*

> *"That risk must be avoided. Possibly, this can be settled with specific orders in the procurement to ensure that the knowledge collected by the contractor is returned to us as a customer." - Hall*

Palm describes how ownership and control of data are important questions within Stockholm's smart city initiatives in order to allow for the flexibility to change vendors:

> *"We must ensure that we as an organization can own, determine and control our own data for a variety of reasons. […] we must be able to ensure that we can bring data to the next supplier." - Palm*

Trana discusses how many smart city functions in the end will depend on how and if enterprises and municipalities can figure out business models that works despite demands from municipalities. Lahti raises a similar argument where he claims that there are no easy ways to solve this. One possible solution, he argues, lies in developing the smart city on a horizontal level with horizontal collaborations rather than "vertical drain-pipes". More specifically, Lahti believes that it is preferable to find suppliers that do not control the entire chain from sensors to data storage and processing.

5.1.3. Flexibility - Transformational

Although most of our interviewees approach the smart city as an opportunity to deliver more effective and efficient public services through the use of ICT-based technologies, their respective smart city initiative extends to more aspects of the city. As described in previous sections, smart cities will require new ways of organizing and solving problems in society. Described earlier, one example of this changing dynamic is how municipalities are in risk of ending up in various lock-in situations with the enterprises that deliver the necessary technology and knowledge of the smart city. In this section we present answers from the practitioners reflecting on the wider societal flexibility issues of smart cities and how they evolve. Worth pointing out here again is that all the studied smart city initiatives are the

product of municipal political decisions, often closely in collaboration with various enterprises.

Following aspects connected to transformational flexibility were identified in the analytical framework (Part I):

- *Involving citizens*
- *How to assess impact of technology?*
- *Transfer of knowledge - changing rationales*
- *Reversing the system*

How to establish smart city solutions in the city is going to be, among other thing, a matter of involving citizens. Several interviewees respond to this quest as something important both for democratic reasons but also for reasons of efficiency. For example, Landahl experience that smart city solutions often are propelled by corporations aiming to do business but where a much better and efficient strategy would be to do it the other way around, where we are perceptive to the existing needs in the city. In the municipality of Helsingborg, the tagline for their smart city development is "dedicated citizen". As Lahti elaborates:

> *"It's a good embryo to what we actually want: a co-creation" - Lahti*

More precisely what co-creation or more generally the involvement of citizen comprise is harder to pinpoint. Some interviewees seem to suggest that citizen involvement is facilitated by initiating common and open platforms for sharing data. Here, citizen can use data provided on the platform to develop applications that come in useful for others. Others seem to suggest that those services and applications that are most used represents what citizen wants. As Kisch imagine the breakthrough of the smart city:

> *"the day that [the smart city] will breakthrough is the day that the citizen notices what benefits, services and values that one gets" - Kisch*

Attached to this topic is questions of who decides what is efficient and how to create a city which gives room to both proponents and opponents of a certain smart function. Palm argues that one might have to plan the city to function both with and without some smart functions.

> *"We must respect that and that they are able to stand outside this. [...] those who do not want to be connected and do not want to be involved in this. They must also have space in a city in the future. This opt-out feature must be built-in from the beginning." - Palm*

Kisch and Trana, from the municipality of Lund, talks about how one way to include the interest of citizens is to measure behavior and habits of citizens and from there see how one can create more beneficial and effective solutions. They argue that one area in which this could materialize is in the urban planning department. Kisch reasons that smart city solutions can help us to better understand and predict what we need. Several interviewees claim that this ability to predict and understand the city will be made through complex algorithms interpreting data. One question stemming from this is who gets to develop these data analytical tools and what kind of presumptions that goes into them. These are highly technical issues, however, according to Landahl they will have a large effect on the outcome of decisions and will most likely be very hard for almost everyone to understand. Trana argues that this might become a problem but where he also points out:

> *"Already today we do a lot of assumptions in for example urban planning. Perhaps it in some sense would be easier to get insight into what lies behind different decisions." - Trana*

Reflecting on a scenario where more decisions in the city are made on the basis of advanced data processing and analytic tools, Lahti wonders whether the basic needs of citizen have to be catered to in another way:

> *"There is a nice word in Swedish which is used internationally: ombudsman. One could have a citizen ombudsman that supervise and to whom one can pose questions like: 'we intend to develop this solution based on AI [Artificial intelligence] that will predict this and that and it's important to have these input parameters do guide it in a certain direction; is that okey? Is it ok to use municipal data for this solution?' In such a scenario a citizen ombudsman could pause for a moment of reflection. To consider where we are heading and why." - Lahti*

In the same vein, being able to critically examine and understand what parameters and assumptions that go into such processing and analysis of data is, as Landahl suggests, in the end a matter of trust. Here, Kisch argues that one might be in need of certain criteria to be implemented in order to ensure certain values in the process of becoming smart.

> *"I think we need to develop design criteria on how to look at questions relating to whom data is for and who should have access to it. We need to find a way where we know what will be effective, but not at any cost." - Kisch*

Apart from being flexible in the development and implementation of certain smart city solutions, one also has to consider aspect of flexibility in regards the ability to change or reverse a once implemented system. This in order to adapt to new circumstances, be it the

loss of certain technical systems, political fluctuations, economic recessions, external dependencies, etc. Hall raises an issue regarding societies getting used to and adapting to a certain technological solution:

> *"The problem is probably when we become so dependent on something that we no longer think about it. The computer, the internet or whatever it may be, we do not think about it when it's there, just when it's not there." - Hall*

Responding to the question of how societies would handle a situation where the municipality, for example, would end up not being able to afford to manage or to pay for certain smart functions, Lahti argues that this is rather common already in our modern societies but where he elaborates that this question might become accentuated in smart cities. Perhaps the main issue, he argues, might be in regard to the new high-tech infrastructure that the municipality doesn't own, where many urban functions to a larger degree in the smart city relies on few large enterprises.

Flexibility - Outlook & Analysis

Approaching flexibility, as shown above, is in large a complex matter consisting of many components that together potentially reduce or enhance the ability to undergo change in order to face new circumstances. Firstly, we approached transitional flexibility. This part primarily focused on the internal affairs of planning for and implementing smart cities. Here several interviewees agree on the notion that enterprises will come to play a greater role in how we organize and solve societal problems. This, most interviewees argue, will come with new challenges accentuated by their smart city initiatives.

The most prominent response to how municipalities can avoid lock-in effects is to strive for open standards, which in the end is seen to open up for collaborations between many actors and hence allow for flexibility. Apart from this, most answers differ regarding the magnitude of challenges that this poses. Many questions posed were deemed relevant but where the interviewees argued that they simply hadn't worked on the issues due to, what they refer to as, the often early phase and small scale character of their smart city initiatives. Rantakokko, engaged in the conversation on smart cities at the European level, do reflect on challenges of maintaining the ability to change or reverse those dependencies that the smart city may entail but adds that such questions are not really at the heart of the EU partnership that he's involved in. In the EU partnership on digital transitions there is rather, what he says, a positive attitude intended to kick-start the partnership's work. This has shown to be a reoccurring answer with regards to many posed questions. This speaks to the fact that the

question of *when* might prove a critical factor in order to understand both robustness and flexibility.

Furthermore, path dependency and lock-ins are often approached as a procurement issue, where the various municipal departments are responsible for placing correct and sufficient demands. It seems as if it is here, many interviewees argue, one should solve many questions of cyber security, privacy, etc., as well as sorting out questions of storing, interpreting and owning data. It follows that developing the right competence is crucial for the ability to approach many of the most pressing questions of both robustness and flexibility. The benefits and disadvantages of such an approach is difficult to speculate about however one question that arises is how to, in such a system, assess the more holistic and long-term consequences, when primarily dealing with these questions in a particular manner from case to case.

A broader approach, as suggested by Kisch and as partially conducted in Stockholm, is to develop certain design-criteria which could ensure certain values to be considered in the planning and implementation of various smart city solutions. Onland elaborates on design-criteria developed in Eindhoven smart city, where the aim with the so called *IoT chart* is to safeguard certain values and principles. Onland describes how this chart, although beneficial in many senses, have created a situation where the collaboration with enterprises has become more difficult. He concludes that one reason for this is that it often aligns poorly with business models developed by enterprises. Hence, one challenge here is how smart city solutions successfully can merge into an existing urban fabric taking into consideration the multitude of values develop over a long time.

Onland describes how the principles put in place in the IoT-chart may also have an effect on the efficiency of the various smart city function. For example, if one is to restrict the use of data for perhaps integrity reasons, this might reduce the efficiency of the application or function. He goes on to describes how citizens will come to play a major role in the development of smart cities, through which applications they choose to use. Onland describes how many tech companies, often giant tech corporations, acts on a global scale and can derive data from the use of their applications without taking into consideration any of the principles on the local scale set up by the city. Hence if a city or an enterprise bound to a smart city initiative wants to develop a function considering certain design-criteria, they will compete with companies who potentially could develop more efficient applications because they don´t abide by the same rules. Citizens may here come to act as the final judges, be they well- or poorly informed, navigating the tortuous trade-offs between efficiency and other values.

This development of smart cities where the population becomes included could help see to a development that serves public- or at least individual interests and hence perhaps cater to flexibility. However, deciding what people want on the basis of how they consume a particular product might come at the expense of what happens over a longer time span. One potential risk is that this, in the end, might result in potential lock-ins due to the fact that the efficiency of many smart city functions resides in how much data it has access to. Applications not embraced by citizens, will become less used and hence less and less efficient. The most used applications in the in the early phases might over time come to be very difficult to challenge. This could be even more accentuated by what Kramers says "the starting field has already gone".

One could argue here that smart cities, from this perspective, opens up the space of the city to various enterprises, where power resides in how efficient people find a certain application. Over time as people have acclimated to a specific application, there is perhaps no viable alternative and hence there has formed a lock-in effect resulting in a situation where societies potentially lose the ability to be flexible and change course. This could also result in enterprises having a lot of influence on how our cities develop and how citizens behave.

One challenge here is hence how smart cities, from the perspective of the municipality, can handle a situation where flexibility can be catered to, while at the same time allowing for an open arena for competition. Not being able to place demands, be it beforehand or to change demands after hand, could be seen as a reduced ability to be flexible. Onland here argues that some of these questions might be too difficult to handle on the urban level and where a potential solution might come through legislation at the national or European level.

There seems to be many challenges for retaining flexibility over time in smart cities, however as pointed out by some of our interviewees, smart city solution might come to prove less sturdy than previous infrastructure implemented in our cities. Sewage pipes, roads, and building lasting many decades perhaps centuries, creates a foundation as Winner (1978) and Geels (2004) describes it, with which we potentially have to organize around and co-evolve with over a long time. This is likely not how the digital infrastructure will develop, both Hall and Onland describes how the development of new technology is so fast that one has to speculate and try to predict what the next technological breakthrough might be in order to not waste time and money. Departing from this we might expect a development towards an ad hoc development of cities where we create new rooms and new functions but where these

are of more temporary nature. This could potentially also open up for new feedbacks and hence be more flexible to political fluctuations, citizens influence etc.

However as pointed out many times, there are also other aspects to consider here. One of them reflecting on the points made by Kitchin and Dodge about creating code/space where the functions of rooms depend on the function of technology. This we've argued is a potential reality on an urban scale if smart cities materialize as envisioned. This would lead to us changing the ways we organize and behave in certain rooms and also potentially come with a greater dependence on certain actors and technologies for our daily lives. A removal of these functions would hence become on an urban scale potentially disastrous which hence reflects on an increasing path dependency and lock in effects developing over time.

6.0. Concluding discussion

As we understand smart cities, this urban development ideal entails challenges that may affect the ability of the city to withstand stress without loss or unwanted corruption of function as well as to maintain an ability to change and adapt. In short, this is what we call challenges of building a robust yet flexible smart city and, as presented in Part I, what we conceptually aimed to scrutinize in our analytical framework.

As a point of departure, this analytical framework has guided our exploration of experienced challenges in building a resilient smart city in practice. The results from this empirical curiosity, elaborated on in Part II, testified to, casted new light on and brought forth novel aspects in regard to previously identified challenges of building resilience in smart cities. Taken together, these both theoretical and practical perspectives on the smart city amount to a comprehensive yet incomplete conception of what seems to be the most pertinent challenges in building resilient smart cities. As a concluding discussion, we provide four overarching challenges where many smaller as well as larger challenges converge.

6.1. Four pertinent challenges for building resilient smart cities

In order to build robust yet flexible smart cities there are clearly many challenges but also some solutions to mitigate these. Here we won't go into depth on each of these already discussed matters, instead we aim here to capture these matters under more aggregated themes that are of more encompassing character. Within these there are certainly interesting point to elaborate further on.

Keeping pace with threats

What seems to be evident is that the smart city accentuates certain challenges in terms of building robustness. Primarily, these challenges revolve around the emerging risk landscape that follows from increasing the conflation between the city and smart technology. Although the dependency on ICT is an increasingly defining feature of modern societies of today, the smart city extends this dependency on a wider scale. In extending this dependency, where the proper functioning of modern technologies is the difference between something happening or not, the smart city introduces a different and larger attack surface. First and foremost, we've conceived of this emerging attack surface as a concomitant part of

instrumenting the urban physical fabric with numerous smart devices. The most pertinent challenge is whether the smart city can be defended against the complex of threats that potentially could exploit that attack surface. To keep pace with threats is a daunting task. Additionally, where in theory effective defense strategies could be put in place, in practice, though, this challenge becomes no less pertinent. We conclude that this is so because the smart city fosters the relationship between the ICT-industry, as the main vendor of smart technology, and the municipality, as the main purchaser, in which the latter have to put proper demands for robustness enhancing measures. The real challenge here resides in the question whether the municipality have the capacity to mobilizing resources (e.g. competence and costs), in a context where those are limited, to at least try keeping pace with threats. Moreover, the fact that any organization is constrained by available resources may lead to a likely scenario in which cities with appropriate amount of resources has greater opportunity to enforce a smart and robust city while, in a context where such resources are scarce, the city might be smart but perhaps frightfully vulnerable. Such a scenario can be conceived of at multiple scales, not only in a difference between richer and poorer cities, but as in an uneven development between places within the city; between one region and another; between one nation and another etc. Hence, the burning question is how the smart city can embark on a development that do not ignore and enlarge socio-spatial injustice but rather contribute in combating it.

***When* to approach challenges**

Through the advancement of technological solutions, the smart city holds promises of optimizing the way the city is organized and managed as well as invitations to entirely new solutions to urban problems. However, when promises of optimizing functionality and experimenting with novel solutions come at the expense of attending to challenges of building robustness yet flexibility then such challenges are postponed to a near or distant future where they are not easier (if they ever were) but harder to handle. Without proper attention to non-functional aspects in the planning and implementation phase, such as safeguarding smart technology from various intrusions and attacks, the smart city becomes a stranger to the notion of robustness. Additionally, where there is a conflict between experimenting with and promoting benefits of the smart city and attending to challenges of how citizen, in several yet complex ways, partake in the process, profound questions of how the city may cater to an ability to change and adapt are left untouched. Thus, we conclude that *when* to approach challenges that the smart city entail is of outermost pertinence from a resilience point of view.

Efficiency vs. other values

There seems to be an inherent contradiction between on the one hand striving for the most efficient smart cities while on the other hand cater to other values. This is clearly a challenge when approaching a high-tech urban ideal that strive for efficiency while simultaneously entering a social system. This in terms of both robustness and flexibility, which hence also reflects on the challenge of building resilience.

In general, these challenges seem to stem from firstly the new division of roles in the smart city, and secondly, the nature of how smart technologies develops. As understood here there will be new private players being part of creating the desired efficiency but where a question arises if the most efficient actors can be challenged as they become more and more efficient, placing cities in a situation with little flexibility. This also becomes accentuated by the fact that placing demands through, for example, design-criteria can reduce the potential efficiency for actors abiding by these rules, opening up the smart city to more efficient global actors who can play the same game but with no restrictions. The openness and competing aspects of the envisioned smart cities might in the end result in a reduced flexibility.

The resiliency question is if societies over time becomes more and more dependent on certain actors shaping our urban functions to a point where the loss of certain of these functions would be catastrophic. Catering to resilience might over time become a matter of the interests or survival of certain enterprises. Putting the genie back in the bottle will most likely become a difficult task as cities becomes ever changing hybrids at the hands of whoever creates the most efficient solutions.

Pragmatic approaches vs. holistic understanding

This part reflects on many issues connected to the aggregated effects of smart city initiatives. The development of smart city initiatives suggests an often pragmatic and particular approach. One simply wants to harvest the potentials of technology, where the driving forces lies in the benefits and not in the adverse effects. Here it seems as if though new technologies are dealt with as neutral matters, where it is perceived of as simply creating the functions we want to have. This reflects on what Winner refers to as the sleepwalking effect, where he argues that we often tend to view of technology as a function of the present but lack the long-term perspective of how it changes our everyday lives and how we think. It seems as if the smart city development is more of a constellation of

municipal institutions together with enterprises striving towards simply becoming more efficient.

In this study we've argued that smart cities may very well come with challenging lock in effects and path dependencies that probably does not lie in the interest of citizens. This, we conclude, has much to do with the challenge of thoroughly grasping the impact of technology as a determining factor of how the city develops. Although the impact of smart cities can and is judged by its contributions to inter alia efficiency of delivering public services, reduction of environmental impact and channels for public participation, at least in the practical implementation and planning phase, the more holistic perspective on how the impact of technology-centered urban development affect the ability to maintain a higher degree of flexibility still remains as an unsolved pertinent challenge.

7.0. Further research

Our study has in many ways been an exploration of challenges that the smart city potentially poses in regards to building resilience. The motive behind this approach was that the combination of resilience and smart cities was deemed as relatively unexplored and as such we argued that there is room to more generally map out challenges in the smart city and try to frame such challenges from the point of resilience. For further research it would be interesting to take this exploratory outlook further into practice and elaborate more concretely on how resilience can be assessed in the smart city context. Amongst many things, this could entail the indexing of various indicators and measures that both quantitatively and qualitatively can encircle the inexhaustible question: is the smart city resilient?

Furthermore, as we recently discussed, the geography of places within the city, between cities, regions and nations is uneven in many ways. Perhaps most evidently in the difference between financial resources - that is, there are more wealthy places and less wealthy places. For further research it would be highly interesting to investigate what this might entail in regard to the development of smart cities in general, for smart cities in the perspective of resilience in particular. We have only touched upon this issue and indicated that it is likely that places, like a municipality or certain parts of the municipality, that have less resource might be able to push for becoming smart but at the same time have greater difficulty in not becoming more vulnerable in the process. Although not underestimating the task of becoming smart, this study finds that becoming smart *and* at the same time coping with risks and vulnerabilities in the process is a task far more challenging. Further research could delve deeper into such contextual parameters and more thoroughly examine the possibilities and challenges of developing resilient smart cities not only as isolated islands where the right amount of resources exists but also where such resources are more scarce.

8.0. References

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Appendix I. Interview guide (translated from Swedish)

Information about the informant

- Where do you work and what is your main work task?
- How long have you been in the profession?
- What is your role and relation to the smart city?

Introductory questions on the smart city

- How would you define the smart city?
- What characterizes the smart city?
- What is the main purpose of becoming a smart city?

Challenges in building a resilient smart city

- In regards to your smart city initiative, what projects are you working on? What are the prospects?
- Who initiated the project?
- What are the benefits and merits of your smart city project?
- Generally, to you see any challenges and apprehensions in regards to your smart city project?

Robustness

Virtual dimension

- How have you reasoned in regards to cyber security?
- Are there any threats and risks?
- How vulnerable is the solution/service/system to threats?
- How have you reasoned in regards to costs of cyber security and especially if the project would be implemented on a larger scale?

Physical dimension

The virtual dimension of the smart city is arguably intertwined with a physical dimension and larger physical infrastructure that it depends on:

- How have you reasoned in regards to such relations of dependency? More specifically in terms of risks and challenges?

- Are central and critical components of the solution/service/system exposed? Are they easily accessed and more or less easy to outmaneuver?
- Do you reflect in terms of back-up systems? (e.g. battery back-ups in case of power outage)

Organizational dimension

- How is the division of roles in the project?
- Who is responsible for what?
- Do you have any plan for circumstances of disturbance and perturbations?
- Is there any preparedness for a scenario where some smart city solution/service/system, which the city has become dependent one, collapse?

Flexibility

- How is the division of roles in the project?
- Who is responsible for what?
- How have you reasoned in regards to financing of the project, in short- as well as long-term?
- How have you reasoned in regards to what suppliers and vendors that you cooperate with? Is there any possibility to change supplier and vendor once a solution/service/system has been implemented?
- Who will own data?
- We suspect that raw data from e.g. sensors have to be processed, analyzed and interpreted: Who will be in control of that part? Additionally, this process, where data becomes information and knowledge, is that a transparent process that e.g. citizen, public officials, decision makers could form an opinion on?
- How can citizen be part of the smart city development?
- In becoming smart, what do we get and what to we give up? It might be a likely scenario that we as a smart city are, so to speak, climbing up a ladder of technological development (reaping the harvest of benefits thereof) but are we able to work in such a way as to have to opportunity to climb down that ladder?