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Digitalization of Municipalities Through Ecosystem Cooperation

How can municipalities realize value from digitalization through ecosystem cooperation?

Master's thesis in Industrial Economics and Technology Management
Supervisor: Per Jonny Nesse
July 2019

Master's thesis

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Problem Description

The digitalization of municipalities is more relevant than ever, with a potential multi-billion dollar realization value if successfully accomplished. Emerging technologies and new ways of doing business contribute to new and innovative projects and solutions, where certain municipalities are front-runners and others fall behind. In the recent years, ecosystem thinking has appeared crucial in order to understand how interdependencies between actors are addressed to enable business development across sectors.

The purpose of this master thesis is to research how municipalities can realize value from digitalization through ecosystem cooperation. The findings will be analyzed based on how the municipalities cooperate with the actors in their ecosystem, with respect to different types of value. The results will be thoroughly discussed using relevant literature, and compared to national and international research.

Assignment given: January 15th, 2019

Supervisor: Per Jonny Nesse

Preface

This thesis is the final work of the Master of Science program of Industrial Economics and Technology Management, within the field of Strategy and International Business Development, at the Norwegian University of Science and Technology (NTNU). Our work on this subject started in August 2018, and this thesis is partially based on a systematic review of literature we published December 2018.

The aim of this paper is to investigate how municipalities can realize value through ecosystem cooperation. Our research will be presented in the form of an academic article aimed for publication in a scientific management journal. The article will be complemented with supplemental theoretical background, methodology and insights into the current situation on digitalization in the public sector, for those who wish to go in-depth on the topic. It is targeted towards academia as well as public and private actors where digitalization and ecosystem thinking is relevant.

We would like to thank our supervisor, Per Jonny Nesse for providing great insights and support along the way.

Trondheim, July 2019

Hans Chang and Katrine Selnes Mikalsen

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1 Introduction

Across the world, cities and industries have begun initiating digital transformation. The age of digitalization is revolutionizing every industry, and has been coined the fourth industrial revolution (Park, 2018; Matzler et al., 2018). The technologies have reached high maturity at a low price, so now is the reliable and economically profitable time to digitalize (Kvist, nd). Different actors are seeing the benefits of the technologies, and many have emphasized digitalization as a crucial strategic agenda (Warner and Wäger, 2018). It is estimated that the total benefit realization of digitalization in Norwegian municipalities will reach over 100 billion NOK over the next ten years (Mellbye and Gierloff, 2018). We have now reached the point where businesses have to digitalize to be able to compete, survive and thrive.

Digital technology also changes society, with respect to how citizens live and work (Matzler et al., 2018). New product offerings are sweeping through the world at a rapid pace. Furthermore, digitalization has taken another leap with the emergence of Internet of Things (IoT): small devices with sensors and actuators that are disrupting industries (Dijkman et al., 2015). When combined with other products and services, the IoT is driving the digital transformation in the industry (Chambers, 2017). The traditional concept of business models has been crucial in order to understand and analyze businesses for the past decades. However, recent research on business models in the context of digitalization and IoT has moved from the firm perspective to an ecosystem perspective, where firms puts emphasis on cooperation within their network (Westerlund et al., 2014). The connective nature of emerging technologies has sparked a change in the way of doing business, and traditional business model frameworks are often questioned and deemed inadequate (Dijkman et al., 2015; Metallo et al., 2018). Rather than focusing on individual firm benefits, firms need to identify competitors and collaborators in the ecosystem while maintaining awareness of their own role.

The IoT is not only for the industry to leverage, and the digitalization of municipalities is more relevant than ever. Several Norwegian municipalities have started developing smart city programs while others have not yet formalized the digitalization strategy. Certain municipalities have also been internationally recognized in a smart city context. Bergen has been awarded for the development of a smart vacuum waste collection solution, by the Smart City Expo World Congress (2018). In a municipal context, there are many actors with different responsibilities and expectations. Cooperation towards digitalization is important in order for future projects to be environmentally friendly and globally profitable (Kvist, nd). Network thinking is important in order to identify and define new business opportunities (Ghanbari et al., 2017). Different theories and variations of renowned frameworks such as the quintuple helix model by Carayannis (2019) have become popular among scholars in order to understand how the cooperation among different actors takes place. This has led to new frameworks being developed to understand the dynamics and complexity of digitalization for both private firms and the public sector.

Existing IoT research is often focused on the technological requirements for companies to construct information-sharing systems, rather than the reasons why companies should participate in the sharing of information on materials (Hakanen and Rajala, 2018). Thus, we realized that research on the value realization would be necessary to increase the knowledge about the current status of digitalization in an ecosystem. The public sector employs a large proportion of Norwegians, and we lack knowledge about certain aspects on how different elements of the ecosystem are focused on by municipalities. In addition, Norwegian smart city development is mostly done by municipalities and reports often mentions municipalities rather than cities (Mellbye and Gierloff, 2018; Rambøll, 2018; Kommunal- og moderniseringsdepartementet and Agenda Kaupang, 2018). Thus, we arrive at the following research question:

How can municipalities realize value from digitalization through ecosystem cooperation?

The concept of value will be divided in two parts: *quantitative* and *qualitative*, and will mainly be related to the municipality itself and its residents. In an ecosystem, value created for a third-party could have impact on the benefit realization for the municipality. However, these instances are rarely documented or mentioned by the municipalities themselves, therefore we leave it as a topic for future research. Literature on what the ecosystem entails and how it is built up will be presented in the next chapter. We will go beyond the scope of *firms* and look at different actors within the ecosystem.

Digitalization is defined in a series of different ways, and Brown (2017) simply calls it an *increase in digital activities*. Another good description is by Laya et al. (2018) who says that *digitalization is not only about increased efficiency but also about the opportunity to offer new services or to offer them in new way*. Meanwhile, cooperation is hereby defined by: *Firms interact with each other and combine complementary know-how or resources to achieve a common goal* (Ghanbari et al., 2017). There are, however other types of relationships in ecosystems such as competition or coopetition that could be relevant to investigate in this context. However, it is considered beyond the scope of this thesis, and we will thus initially focus on cooperation.

1.1 Aim and contribution

The aim of this paper can be divided in five parts: (1) To obtain and discuss current literature on ecosystem thinking and municipal digitalization. This will be done in the next chapter by presenting systematically sourced, relevant literature on the relevant topics. (2) To identify relevant ecosystem actors, and how the cooperation with the municipality takes place. Empirical material will be collected, analyzed and presented in the form of an academic article. (3) To identify the different types of value that can be realized in municipalities in context of digitalization. This will be done using broad classification research combined with in-depth case studies of municipalities that are further ahead in the digitalization process, compared to the national average. (4) Use the empirical evidence to find common approaches and discuss potential strengths and weaknesses. The article will contain cross-case comparisons and analysis of all findings. (5) To discuss the potential limitations and managerial implications of the findings. The results will be discussed and concluded by the end of this paper.

The contribution for this report is to provide useful insights on the field of digitalization through ecosystem cooperation in municipalities. The ecosystem perspective is relatively recent within this field, and only limited amounts of research is already available in the municipal context. Given the concept of cooperation being included in the research question, this paper should be relevant for a series of actors outside the municipality, and serve as a collection of guiding perspectives. The theoretical background will be described in detail, and serve as a basis for the report. Both relevant background literature which is used to support our arguments and current research from similar studies from other countries will be included. The literature search is systematic, but also complemented by relevant research from other sources in order to represent the current research base as thoroughly as possible. In this way, the literature base can and will be used in future ecosystem research within the field of digitalization in the municipal context.

The paper is built up in the following way: First, the choice of research question will be introduced, together with its scope and contribution. Then, relevant literature will form the theoretical background, followed by a presentation of the chosen methodology. Then, empirical material will be utilized to answer the research question in the form of an academic article, aimed for publication in a scientific management journal. Through 26 ongoing digitalization strategies representing 58 municipalities, together with five in-depth case studies of municipalities that are further ahead in the digitalization process, we aim to investigate the current situation of digitalization in municipalities. Following the article, some concluding remarks will be presented with regards to the theoretical implications and limitations of our work.

2 Methodology

In order to obtain a theoretical basis for this paper, the chosen methodology starts with a systematic literature search, as described by Tranfield et al. (2003). We will present the initial theoretical selection criteria in the form of a review protocol, and afterwards explain the secondary round of exclusion. As an additional search was done to supplement the theoretical background, the same process will be documented for the supplemented search. The resulting literature will serve as the theoretical basis of this thesis, and are presented in section 3. The empirical material used to conduct our research will later be presented and analyzed in section 5.

2.1 Theoretical review protocol

A review protocol is created, consisting of a set of rules to make the theoretical basis representative of the current knowledge within the field. It helps to protect objectivity by providing explicit descriptions of the steps to be taken (Tranfield et al., 2003). The protocol is designed to dismiss all material that does not relate to the topic at hand. The first step of the review protocol is to determine where to extract the data to be used in the review. To ensure quality of the result, only academic articles from recognized peer-reviewed journals are reviewed. These articles are limited to the material that is accessible for students at the Norwegian University of Science and Technology (NTNU). In order to conduct this search as efficiently as possible, the university library database *Oria* will be used. This database provides us with all printed and electronic books, articles, journals, and published theses of all Norwegian academic libraries that we have access to.

2.1.1 Primary search

For the primary search, the central role of business models and value creation in the research question lead us to solely include articles that at some point mention *business model* and *value*. Furthermore, we choose to limit the findings to materials that either include *public sector* and *digitalization* or directly contain *internet of things* or the abbreviation *IoT* as they were important themes for our empirical data. Given that the findings were still numerous, and within a series of different research fields, we set a series of criteria for the subject area. Either *innovation*, *ecosystem*, *network* or *connectivity* therefore needs to be listed as a topic in order for the article to be initially selected. This variety of topics was found necessary in order to not limit the literature base to the point of leaving us with less articles than recommended for a reliable basis. The exact wording of the search is presented below:

Search terms:
Article includes:
- "business model*" AND value
- ("public sector" AND digitalization) OR (iot OR "internet of things")
Research/subject areas:
- innovation OR ecosystem OR network OR connectivity
Refined by:
Published:
- Any time
Content type:
- Article (peer-reviewed)
Language:
- English OR Norwegian OR Swedish

We chose to not limit the search by publishing year, because the research on the chosen topic is relatively recent. The full search provides articles from 2006 onward, and further restrictions by year were therefore found to be redundant. We used the same search criteria and limitations in both databases. After running the search we ended up with a total of 241 articles, but not all of these were found to be relevant for the review question. We therefore had to set up a number of secondary filters, to further limit the sample size. The exclusion criteria of the secondary filters are worded below:

Secondary filters for exclusion:
- Does not have business models or IoT as a core theme
- Aimed at a specific technology and does not discuss the case from a business perspective
- Unobtainable

To determine whether the article met any of the secondary exclusion criteria, the abstract of the article was read. If there was any element of uncertainty, the paper was read in its entirety to settle any doubt. After iterating through the initial search and the secondary filters, we were left with a pool of 111 relevant articles. We decided to not add further limitation criteria, to ensure a sufficiently broad basis for the following research.

2.1.2 Supplementary search

A second search was conducted to further supplement the theoretical background. As we recognized that many articles does not mention the word digitalization while discussing smart cities, we chose articles with *smart city* or smart cities in the title. Our intent was also to discover the applications of frameworks to analyze smart cities which lead us to also filter on title including *case studies*. During the case study, we identified the helix framework as relevant in order to research the co-operation in the ecosystem. As it was quite frequently mentioned, and seemingly recognized among scholars, we choose to expand our literature base by articles containing the word *helix*. Similarly to the first search, we did not limit the search by publishing year as the chosen topic is relatively recent. The full search provides articles from 2011 onward.

Search terms:
Article includes:
- helix
Title includes:
- ("smart city" OR "smart cities") AND "case studies"
Refined by:
Published:
- Any time
Content type:
- Article (peer-reviewed)
Language:
- English OR Norwegian OR Swedish

After running the search, we ended up with a total of 6 articles. To further limit the sample size, articles aimed at specific technology and not discussing the case from a business perspective where excluded. Table 2.1 shows how many articles where approved after each stage of the selection process. We ended up with a literature base consisting of 113 articles, which are all presented in section 3.

2.2 Characteristics and quality of theoretical basis

The basis of the following synthesis consists of 113 peer-reviewed articles from different scientific journals. Having material from different fields of study is deemed positive, as the literature review is more likely to grasp a broader picture of the current state of research. There is a moderate spread in publishing, which is shown in

Search	Search terms	Secondary filtering
Primary	241	111
Supplementary	6	2
Total		**113**

Table 2.1: Number of approved articles after each stage of the selection process

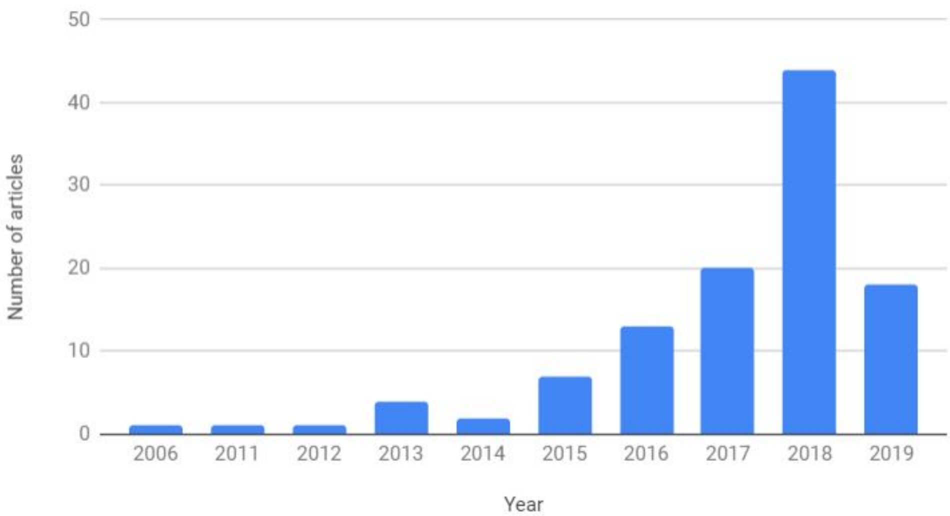

Figure 2.1: Distribution of articles by publishing year

Figure 2.1. The articles range from 2006 until the current year. It is of interest that approximately 56% of the chosen articles were published over the last two years.

2.3 Methodological challenges

There are several elements of uncertainty and limitations to consider. The systematic review depends heavily on the chosen search terms. The inclusion and exclusion of relevant papers was done following a predefined protocol, but may have been subject to bias. The process is often done with a third external party using different validation criteria, but given the limited amount of resources and time, this task was only done by the two researchers. Although the choice of keywords and search terms was done in a systematic manner, some important words may have been overlooked. This may have impacted the quality of our final selection of papers and the broader knowledge of the field.

Time was also a significant limitation that could have lead to our scope being narrower. This can have had an impact the result of the synthesis as it can have led to omission of important studies. The time also affected the choice of number of databases that we would search in and which databases we consulted. Two different digital databases was consulted during our systematic literature review which can have led to some relevant studies not being included in the initial search. The chosen database was our university database Oria.no. We believe that the use of additional databases could have had a positive impact on the results.

The filtering process was also liable for a bias. The filtering was done in two phases where the first phase was a reading of abstract and titles in order to evaluate their relevance to our study based on our search criteria for the primary and supplementary search. First impression might have influenced the selection as the first filtration was shallow and quality and clarity might have had an potential influence. The second phase was done by doing a shallow reading of the articles while categorizing them. As time was a factor, clarity was of a big importance and some studies might have been ignored due to quality. The time perspective does not allow us to personally assess all the existing literature of the chosen topics, which might have left important articles missing from this study. Finally, our suggested framework is strongly based on qualitative measures, and the absence of quantitative evaluations could be providing the result with an element of uncertainty. The selection of studies might be subject to bias, regardless of the chosen validation criteria. The quality assurance is based on peer-reviewed articles in recognized journals, which might not be sufficient to ensure all the assessed findings are reliable.

3 Theoretical background

This chapter presents the theoretical background of this thesis. It will provide the reader with the relevant background information for understanding the relevant topics. Furthermore, this theory will be applied in the analysis for answering the research question, and in the discussion for answering the purpose. The chapter is structured as follows: first the general theory of business models are presented to provide the foundation for understanding the concept. Thereafter, a literature review of business ecosystems in context of IoT and smart cities are presented. Finally, theory on monetizing smart city solutions are reviewed.

3.1 Business models

The first mentioning of the concept of business models was by Bel (1957). The popularity has grown in the years in the industry, but there are many different interpretations such as a statement, a structural description, a representation, an architecture, a tool or a conceptual model, a structural template, a method, a framework, a pattern, or a set of elements (Zott et al., 2011; Morris et al., 2005). The definition we will use was proposed by Osterwalder et al. (2005) as they have had a prevalent impact on business model literature:

> *A business model is a conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm. Therefore we must consider which concepts and relationships allow a simplified description and representation of what value is provided to customers, how this is done and with which financial consequences* Osterwalder et al. (2005).

Business models can be seen as an implementation of strategy to earn money, thus the model describes what firms offer, who they are and how they deliver their product or services. A strong business model will be a good foundation for firms to understand their environment while making them more transparent for stakeholders (Glova et al., 2014; Matzler et al., 2013). The use of such a framework simplifies analysis of business logic by making firms more measurable, observable and comparable while improving management of the firms by simplifying design, planning, changing and implementation of business models (Osterwalder et al., 2005). The informative abilities from the use of the framework is why it has gained popularity and has been a object of research. According to Osterwalder, the reasons of the popularity in management is because of today's managers have many choices when it comes to defining their value proposition, value network, choosing partners, and looking for ways to reach customers. Experimentation with business models are crucial to survive as there has been many instances where firms fail, such as Xerox, due to conflicts between the existing business model and the required one to exploit the emerging technology (Chesbrough, 2010).

Chesbrough (2010) argues that the same developed innovation can yield different returns and that the economic value of a technology remains latent until it is commercialized in some way via a business model. There are numerous ways to commercial a new technology. There are times when the established ecosystem works while sometimes, firms has to innovate their business model. "A mediocre innovation within a great business model will most likely be more valuable than a great innovation within a mediocre business model "(Chesbrough, 2010).

3.1.1 Business model frameworks

Solely product innovations are not enough to work in the market in a sustainable way. Product life cycles are shortening and competition is increasing. Today's new business opportunities stem from unique business models. Firms have to find new ways of generating added value for customers and monetize them (Matzler et al., 2013). To achieve these goals, the concept of business models can be used to analyze firms and organizations. Various frameworks has been developed in many industries and can be very different depending on the firms applying the frameworks.

The business model canvas by Osterwalder et al. (2005) has served as a basis for many developed business models. It serves as a visualization of the business logics of a firm. The framework was derived from a systematic review of relevant business model literature where the models that was most often cited, mentioned, and examined in academic literature generated the basis of their framework. The framework is shown in fig 3.1 (Turetken et al., 2019).

The framework consists of nine blocks that describe the business model. By having a business model conceptualization that describes the essential building blocks and their relationships makes it easier for managers to design a sustainable business model (Osterwalder et al., 2005). A short summary of every building block by Osterwalder (2015) is presented below:

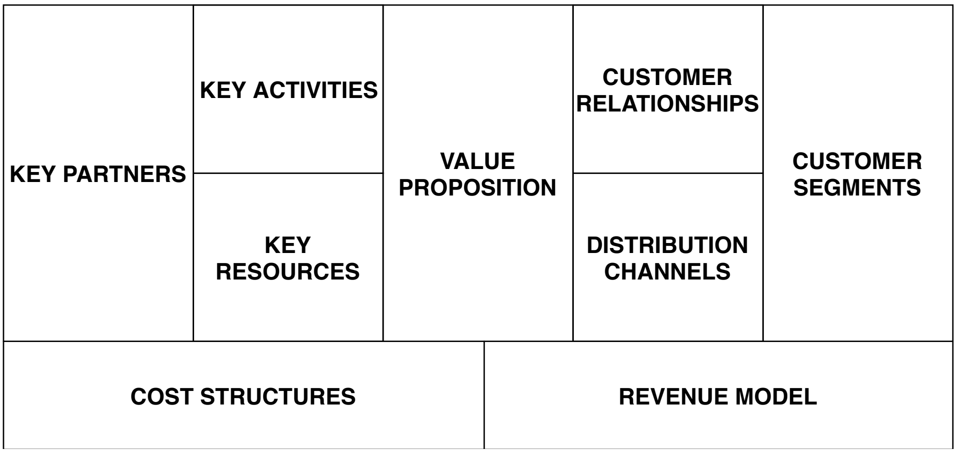

Figure 3.1: The business model canvas (Osterwalder, 2015)

- **Customer Segments** - The different groups of people or organizations an enterprise aims to reach and serve
- **Value Proposition** - The bundle of products and services that create value for a specific Customer Segment
- **Channels** - How a company communicates with and reaches its Customer Segments to deliver a Value Proposition
- **Customer Relationships** - The types of relationships a company establishes with specific Customer Segments
- **Revenue Streams** - The cash a company generates from each Customer Segment (costs must be subtracted from revenues to create earnings)
- **Key Resources** - The most important assets required to make a business model work
- **Key Activities** - The most important things a company must do to make its business model work
- **Key Partners** - The network of suppliers and partners that make the business model work
- **Cost Structure** - All costs incurred to operate a business model

As business models are used to analyze business logics, the concept can also be used to analyze smart cities. Cities and municipalities share many similarities with

Building blocks	Smart city comparison
Customer segments	Users in shops, restaurants, hotels, public services, museums, transport Citizens Visitors
Value Proposition	Increase the participation of citizens/users Customized information based on preferences Increase revenue of private and public companies Improve citizens' credibility about the local Public Administration Increase tourism volume
Channels	Mobile application Websites Delivery
Customer Relationships	Customer experience (e.g. smart mobility and smart health)
Revenue Streams	Citizens/tourists/visitors (for collection of more income taxes)
Key Resources	Technological devices Public relationships Political sponsorship Collective intelligence Interdependencies between service/device/technology Open data platform availability/big data availability
Key Activities	Developing interdependencies between service/device/technology Developing ICT Infrastructure allowing entities to deliver any kind of services to people with complementary multiple devices Multiple-device/platform availability City's own network infrastructure Data center availability and integration
Key Partners	Users co-creation and participation Any actor Infrastructure development
Cost Structure	Administrative and Marketing expenses Storage Communication network Publicity

Table 3.1: Business model canvas applied to smart cities (Schiavone et al., 2018)

firms. Schiavone et al. (2018) proposed a business model for smart cities using the business model canvas shown in table 3.1. The business model was derived by reviewing 11 articles that were chosen after a filtering process and shows how the business model canvas can be applied to smart cities.

There is a variety of approaches in development of business models in the literature in response to the present times where digitalization and IoT are focus points for both the public and private sector. The business model canvas has been widely adopted in practice for designing new business models, but has gotten criticism as it is to focused on the blocks than the relationship between and fails to explain how business models truly works (Westerlund et al., 2014).

3.2 The digitalization era

The rapid pace of technological advancements has led to many calling this as the Fourth Industrial Revolution or industry 4.0 (Morrar et al., 2017). "Global industries are becoming more connected and interlinked" (Robinson and Mazzucato, 2019). To address the globalization and increased competitiveness in Industry 4.0, firms has focused on features such as real-time capability, interoperability and the horizontal and vertical integration of production systems through ICT systems (Arnold et al., 2017). Firms are seeking to create additional value through the provision of services (Green et al., 2017).

"New technologies are changing the economic structure, the society, and the way we work and live" (Matzler et al., 2018). Digitalization and IoT represents for many the growing focus on sensors, connectivity, and analytics (Parida and Wincent, 2019). IoT has the potential to transform how firms deliver innovation, create differentiated business models to enhance customer experiences, and optimize global operation (Brody and Pureswaran, 2015). By combining digital solutions, firms can offer unique services and revenue models (Porter and Heppelmann, 2014).

"Digitalization should be seen as a sociotechnical process that systematically exploits the digital format of encoded analog information" (Tucci et al., 2018). Matzler et al. (2018) present the market as the market leaders suffering to the innovator's dilemma while new competitors emerge. The innovator's dilemma is where the existing business model and the core competencies, that has brought success to the firm, are hindering them in exploiting the disruptive innovations even though it has been sustainable (Matzler et al., 2018). Therefore, it is crucial for firms to be open-minded for business model innovation (Chesbrough, 2010). Digitalization typically begins with the strategic renewal and modifications of the business model such as globalization and fast speed of innovation, that follows digitalization. The changes tends to alter the firm's collaboration approach which will eventually lead to changes in the organizational culture. Agility is therefore a core attribute for firms in the digitalization era (Warner and Wäger, 2018; Kupp et al., 2017; Pisano et al., 2015). Matzler et al. (2018) argues that "digitalization impacts three different levels: digital products and services, digital processes and decisions (algorithms and Big Data) and new digital business models".

Digitalized products and services can be everything from lawnmower robots to trivial products such football with digital technology implemented. In context of IoT, devices often contains sensors and actuators (Brown, 2017). However, as digitization of products provides the potential of differentiation, the competitive advantages will most likely be short-term. To embed traditional products with sensors and actuators are relatively simple and seldom requires disruptive changes in firms. The value creation will be in digital business models rather than just delivering products as sensors and actuators decline in price which leads to an influx of digital products (Matzler et al., 2018).

Another type of digitization is the automation of processes and decisions. Every process that can be digitalized. New business opportunities, effectivizing and simplifying are important values that can be gained Cheah and Wang (2017) through digitalizing. Digitalization will help developed economies to maintain their competitiveness. However, effectivizing and cost reduction are defensive measures and business model innovation is therefore important for long term competitiveness. It is a mistake to consider digitalization only to increase efficiency. The failure of digitalization of products and the digitalization of processes are due to neglecting business model innovation and not trying to find new ways of creating customer benefit and monetizing the value (Nakashima, 2018). In other words, it is about connecting digital products with digital processes and adding new revenue models. created (Matzler et al., 2018). The trend of change in revenue models is the change from traditional ownership transaction to outcome-based models (Hasegawa, 2018).

Many of the digital innovations are disruptive and new business models replace traditional ones to capitalize on the opportunities that digitization provides. Many focuses on quality and sustainability instead of price competitiveness (Park, 2018). However, many underestimates the dynamics and complexity of digitization, and react too slowly and stick to their existing business models.(Matzler et al., 2018).

The emergence of digitalization and IoT has made researches question the business model canvas (Westerlund et al., 2014; Klein et al., 2017; Metallo et al., 2018). With business model canvas as basis, new frameworks are being developed. The most important building blocks in context of IoT was value proposition, customer relationships and key partners (Dijkman et al., 2015; Klein et al., 2017; Kiel et al., 2017; Metallo et al., 2018). This has brought researchers to move towards frameworks that focus on networks and ecosystems as new the notion is that value is created by cooperation, coopetition, coexistance and competition between actors in a network (Ghanbari et al., 2017; Turetken et al., 2019; Vilstrup Hansgaard and Mikkelsen, 2013; Shaw and Allen, 2016). This is supported by Parida et al. (2019) that identified three commonalities. Companies was creating novel offering configurations that was enabled by digital technology, companies needed to focus on understanding customer needs in context of digital solutions and that value creation is done through ecosystem collaboration. Customers are no longer just customers, but serves as a focal point for any service as their needs provides the starting point for service development (Grieger and Ludwig, 2018).

3.3 Business ecosystems

The IoT and the big data it provides, requires competencies from various industries. New ways of Working and a new way of organizing are required and it is the environment that often initiates it (Dutton, 2014). Through a business model that accounts for the ecosystem and the collaborating partners, companies can exploit greater opportunities for improved service, risk distribution, shared accountability and sustainability. Benefits of ecosystems is that they ensure a broader set of resources and increased capacity (Parida and Wincent, 2019; Berman et al., 2016). Therefore, recent literature has moved towards the concept of business ecosystems as businesses in closed systems struggles to evolve in the IoT-industry and rely on factors such as capital, partners, suppliers and customers to create cooperative networks. It is therefore important to understand the different actors, the data they generate, and how they interact. Furthermore, they need to understand the necessary capabilities that need to be developed to achieve the potential (Wilfredo Bohorquez Lopez and Esteves, 2013; Haines, 2016). It is through collaboration that most innovations result (Leavy, 2015). Building an ecosystem is more than just funding an incubator. To successfully build an innovative ecosystem, focus needs to be on the long-term (Haines, 2016).

Leminen et al. (2018) identified four types of business models that emerges in the context of IoT: value chain efficiency, industry collaboration, horizontal market and platform. Value chain efficiency is a business model that leans on closed ecosystems and focuses on standard and single purpose IoT services while in industry collaboration, solutions are seen as standard and single-purpose from the user perspective, but are developed for the uses of industries instead of a single customer. A common interface is principal to develop in industry collaboration. The horizontal market, also called Collaborative Commons, is an open ecosystem where solutions are specific. Leminen et al. (2018) argues that the business model suits IoT well as it aims for open-source innovation, transparency and the search for community while IoT is distributed in nature, encouraging and facilitating collaboration, searcing for synergies, encouraging sharing culture, inclusion and lateral peer production. In other words, it advances the social economy. In this present, anybody can become an entrepeneur or collaborator and share his/her goods and services with one another. Due how well the business model fits the IoT-ecosystem, it has become the dominant business model (Leminen et al., 2018). At last is the platform business model that the horizontal market will eventually transform into. Dominant IoT actors will provide services created by others through their platform and acts as service integrators. The business model focuses on exploiting the IoT-ecosystem by combining the existing products and services in novel ways, and by restricting the use of public interface standards. However, it also denotes a huge potential for remarkable product and service innovations that can disrupt the industry (Leminen et al., 2018).

Through continuous collaboration with other actors, business models and their realization in service compositions, are created, modified and discarded (Turetken et al., 2019). To create an ecosystem, Papert and Pflaum (2017) recommends six steps:

1. Definition of an IoT service that should be realized
2. Definition of the own value contribution(s) for the realization of the defined IoT service
3. Identification of necessary roles that provide the remaining value contributions for the realization of the defined IoT service, in relation to the presented ecosystem model
4. Establishment of the own ecosystem by building up business relationships with companies or actors that represent the necessary roles (cooperation partners) for the provision of the remaining value contributions
5. Negotiations with the cooperation partners about compensation (remuneration) for the provision of the remaining value contributions;
6. Realization of the identified IoT service in cooperation with the partners of the own ecosystem.

Actors in ecosystems has to make active strategic alliances for co-evolution in the ecosystem. Alliances can have different orientation such as "strategy-oriented, cost-oriented, resource-oriented and learning-oriented" according to Byun et al. (2018) and they argue that the most common motives for founding alliances was complementing technologies and gaining competitive advantages .

Jacobides et al. (2018) identified three broad groups in their review of ecosystem literature: business ecosystem, innovation ecosystem and platform ecosystem. The business ecosystem represents the environment that firms has to monitor. The various actors make up the ecosystem and the individual performances are tied to the overall ecosystem, but there is a lack of explanation of how firms mutually adapt. The innovation ecosystem has a innovation as the focal point and a set of components around. The ecosystem is viewed as collaborative relationships where firms combine their individual offerings into a solution. The focus in this group is to understand how relationships between actors create and commercialize innovations. Platform ecosystem focuses on specific types of technologies that includes a platform and the interdependence between the platform sponsors and their complementors. The focus in this group is how the platform sponsors and the providers of complimentary components make the platform valuable.

Westerlund et al. (2014) focused on value networks and believed that value is created by the network rather than individual actors. However, firm-level business models are useful to identify opportunities, create alignment inside ecosystems and be the starting point to create a mutual understanding of the opportunities that can be exploited in a ecosystem-level business model (Laya et al., 2018). It is through ecosystem collaboration that value from digitalization is created (Parida et al., 2019). However, relationship between firms in ecosystems do not necessarily need to be collaborative. cooperation, competition and coopetition are different relationships within ecosystem that affect the ecosystem Leite et al. (2018).

Challenges of IoT

With the multitude of possibilities that IoT offers, the complexity brings numerous challenges including privacy, security, cultural aspects and regulatory issues (Mohammadzadeh et al., 2018). To begin with, the introduction of digitalization and IoT faces challenges. IoT-solutions tend to be a small part of a solution and it might be too specific to be base the firm on. There is also uncertainty or/and lack of knowledge about how to exploit the IoT solution, in other words, which type of service it can be a part of. Similar solutions can be found with different infrastructures that leads to a fragmentation of solutions that can inhibit scalability. Due to the nature of collaboration that comes with IoT-development, distrust and hesitation among actors in sharing common and open platforms and data is identified as a challenge. The same challenge is for business models as firms has shown to be afraid of changing their own business models (Markendahl et al., 2017)

Porter and Heppelmann (2014) lists five common mistakes regarding digital innovation. (1) Companies often fail to anticipate competitive threats where new competitors with superior products and services, such as performance-based business models, emerge quickly and disrupt the industry. Often, firms are seen (2) to postpone innovations, thus enabling competitors capitalize on innovations before them. It was often due to lack or ignoring of information (Parnell et al., 2018). Digitalization creates a high demand for new technologies, capabilities and processes and a common mistake is (3) to overestimate the internal capabilities to digitalize. The five distinct capabilities that firms need to exploit IoT are digital business model development, scalable solution platform building, value selling, value delivery and business intelligence and measurement (Hasselblatt et al., 2018). As knowledge of internal capabilities is important, customer needs requires focus too. With all the technology being developed, it is a common mistake (4) to include functionalities that customers do not need. Without enquiring about customer needs, the value of the product and service offerings often lowers as it often leads to costly and complex technology that customers do not value. At last, (5) firms should not underestimate the importance of security and privacy risks as huge amounts of data is generated as some data might be sensitive and in need of protection. Dutton (2014) argues that there is a high possibility for the loT to undermine important values such as privacy, equality, trust and individual choice if the solutions are not designed, governed or implemented in the right way . Furini et al. (2018) argues that the main challenges for collaboration is the lack of data privacy systems and appropriate business models.

Moreover, because the value of IoT heavily relies on the number of devices and users connected to each other, the solutions need to reach a critical mass to work (Dutton, 2014). Without reaching the critical mass, IoT solutions will have lesser chance of surviving. Gao and Bai (2014) identified perceived usefulness, perceived ease of use, social influence, perceived enjoyment, and perceived behavioral control as motivations for customers in adopting IoT. The most important was perceived value which positively affected adoption. However, perceived risk played an insignificant role in perceived value (Park et al., 2018). Due to evolution and revolution in technology, can make it hard for users to fully exploit the opportunities (Anwar and Prasad, 2018). Ammirato et al. (2019) synthesized a conceptual model for explaining the adoption process. The model consists of three dimensions: initiation, adoption decision and implementation. Each dimension is affected by various characteristics which are: environmental, technology, organization, manager and users.

Furthermore, IoT-solutions has to expect global market players to compete and not be satisified with dominating the domestic markets. Standardization is a principal factor for IoT. The IoT solutions also needs to take social norm into consideration as potential users might not accept the solutions if society does not. Due to globalization, collaboration with the government is also important as IoT solutions might get hindered by legal issues (Dutton, 2014).

Business model innovation in context of IoT

Parida et al. (2019) argues that appropriate business models are principal for deriving the benefits from digital technology. However, as IoT depends on co-creation, it is crucial to focus, create and identify ecosystems, thus focus on the ecosystem-level instead of the firm-level (Leminen et al., 2017).

Identifying actors and roles are principal when creating ecosystems as mentioned in 3.3. Ikävalko et al. (2018); Andersson and Mattsson (2015) identified three types of actors in an IoT ecosystem, ideators, designers and intermediaries with different logics and activities. The ideators explains the market needs by integrating their context and needs with the current market offerings. This communication is one-way. The designers combines existing knowledge components to develop new solutions with the ecosystem and with a reciprocal communication. The most important actor is the intermediaries which are the ones who facilitate knowledge transfer across various ecosystems and creates service innovations with multi-way communication. They are the ones who facilitates collaboration between ecosystem actors. The role of intermediaries are crucial when ecosystems overlap. The concept of actors are often related to other firms and organizations, but Andersson and Mattsson (2015) also sees sensors and other IoT objects as non-human actors that can intermediate. They are able to communicate with other devices and provide information to humans. Non-human actors must be valued as it is often fundamental for the collaboration of actors. The non-human actors can also substitute another actors and managers needs to be aware that challenges can appear. Adjustments and ties towards other actors must be established in order to prevent conflicts.Kolloch and Dellermann (2017) Understanding intermediaries has had a growing interest for understanding IoT innovations (Andersson and Mattsson, 2015).

Andersson and Mattsson (2015); Raunio et al. (2018) stresses about the importance of feedback systems to create network effects when innovating services in ecosystems. They focus on the variables: overlapping, intermediating, objectification of actors and business modelling. Business networks are supposedly open, however, some actors and resources are more connected to each other than others. Business networks are therefore seen as limited with different interdependencies between them. Changes in these interdependencies, such as acquisitions and globalization, are defined as overlapping by them. Therefore, in the case of overlapping, firms need to handle new relationships, changes in old ones and closer indirect relationships. These overlappings happens often in IoT-enabled service innovations due its nature of requiring various competencies and resources that need collaboration with other ecosystems.

3.4 Smart cities

As mentioned in section 3.1, business model theory will be used to analyze digitization and smart city development. However, the ecosystem perspective will be used as it is the direction that business model theory has gone.

In the governing and structuring of cities, leaders treat cities as ecosystems similarly as a extended enterprise where specialized organizations are coordinated and integrated to provide services. The services can either be directly delivered to citizens or be delivered through platform markets where direct interactions between service providers and citizens are facilitated by the city leaders (Visnjic et al., 2016).

There are different interpretations of smart cities. A common definition of a smart city is the use of digital technology to collect, analyze and integrate information of core systems in cities to optimize existing and provide new services to the citizens

(Gretzel et al., 2015; Ghanbari et al., 2017; Okwechime et al., 2018). However, a misinterpretation is that smart cities are solely the usage of IoT-solutions. Cities that only uses independent IoT-solutions are difficult to regard as a real smart city (Furini et al., 2018).

However, independent IoT-solutions are rarely a case as its full value arises from integration with other solutions. Subsection 3.3 mentioned the ability to intermediate between actors which can benefit cities. Connecting actors, processes and data can create opportunities for all actors in society, such as organizations, individuals, communities and countries, to realize greater value than working in closed systems. Values that emerge are economic growth and improvements to environmental sustainability, public safety, the delivery of public services and productivity (Feller, 2017). Additionally, as cities often has similar needs, they might benefit from participating in collaborative ecosystems as one solution might be transferable to another one which suggest the ability of scalability of IoT-solutions (Ojasalo and Kauppinen, 2016).

The IoT does not only facilitate collaboration, but also requires cities to cooperate with various actors such as the industry. The quality of public service that cities offer are enhanced when more data is accessible (Pappas et al., 2018). Big firms has huge amounts of data and therefore, (Almirall et al., 2016) argues that the more data accessibility governments offer, the better public services will be delivered. Therefore, cities need to require and create incentives for the industry to share the data they collect from their users. In order to do so, cities need to develop new business models and a legal frame that provides the industry actors with the economic return they deserve for the data they provide to the final services if they become profitable.

As the smart city development has progressed, smart cities has realized a change in their role in society. Instead of being providers of services, they are seeing themselves to be data facilitators (Almirall et al., 2016). An example is in Finland in the TeleHealth ecosystem. The government acts as the data aggregator, but does not monetize the services they deliver and works for cost reduction (Vesselkov et al., 2018). As mentioned in 3.3, platform models are about integrating different solutions into one platform. In the platform model, the cities play the role of the platform owner. They take responsibility of the infrastructure to connect services to citizens needs and coordinate the financial aspects of services. This is where the concept of business models are advantageous (Almirall et al., 2016).

Values that smart cities are expecting to get can be both qualitative and quantitative, but smart city development has tended towards un-monetized values, in other words, quantitative (Naveed et al., 2018; Watanabe et al., 2018). As sustainability is an often mentioned value and in the context of smart cities, they need holistic approaches and focus on innovative ecosystem collaboration. The collaborative relationships include actors within and outside the city administration. Therefore, cities should focus on enhancing their collaborative relationships with actors even if there are no goals at the present time as it can lead to un-predicted innovation (Kankaala et al., 2018; Ojasalo and Kauppinen, 2016).

To engage various actors in ecosystems, especially startups, cities and businesses has held several initiatives such as incubators, living labs and hackathons. These initiatives addresses new ways for companies to tap into the creativity and innovation (Kupp et al., 2017; Tucci et al., 2018). Tucci et al. (2018) sees "hackathons as a new tool in the innovation manager's toolkit". They argue that hackathons are beneficial for digitalization due to three abilities. (1) its ability to attract and manage crowds, (2) its ability provide insight in digital innovation opportunities and (3) facilitate interactions between start-ups and sponsor organizations.

3.5 Frameworks for analyzing smart city development

Mora et al. (2019a) analyzed recent literature on smart city development. They uncovered five diverging development paths for smart cities which were ubiquitous, corporate, experimental, European and holistic which they have used to derive four dichotomies that challenges smart city development. The dichotomies are (1) technology-led or holistic strategy;(2) helix model of collaboration; (3) top-down or bottom-up approach; (4) mono-dimensional or integrated intervention logic.

The first dichotomy is regarding if cities should let technology drive the smart city development or if they should approach holistically where they try to align the technology to the human, social, cultural, economic and environmental factors (Schiavone et al., 2018; Ojasalo and Kauppinen, 2016; Marcelo Iury, 2019). Appio et al. (2018) identified that several articles in his literature review argued that smart cities should move from a techno-led approach to a more design-driven and human-centric. However, the choices of smart city development approaches has differed from city to city. Mora et al. (2019b) reviewed literature and found that many researches considers the theory of technology-led development strategy to be inadequate and not able to handle the complexity of smart city development as it promotes a technological deterministic interpretation of smart cities that mostly benefits businesses.

Smart cities facilitates collaboration between the actors (Scuotto et al., 2016). The relations between actors in smart city ecosystems can be described by using the helix framework which was introduced by Etzkowitz and Leydesdorff (Carayannis, 2019). There are various versions of the helix framework depending on the number of different actor categories focused on and the mentioned ones in our literature was the triple, quadruple and the latest quintuple helix. Carayannis (2019) reviews the literature on the helix framework and identifies the different helices as following. The triple helix are the relationship between universities, industries and government. The triple helix focuses on knowledge production. The quadruple helix is an extension of the triple helix. It embeds the triple helix with the society or the "media-based and culture-based public." The quintuple further embeds the quadruple helix with the environment or "natural environment." The quintuple helix focuses on the context around the triple and quadruple helix and the idea behind the quintuple helix model is that the implementation of thought and action in sustainability will have a positive impact on society as a whole. Academia,industry, government, society and the private sector are different categorization of the different actors that make up a helix model. The quadruple helix is shown in Fig 3.2.

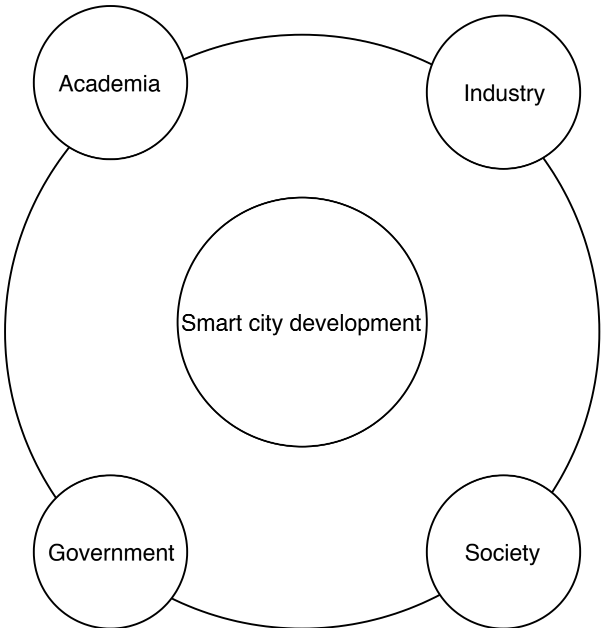

Figure 3.2: Quadruple helix model with digitalization of municipalities in center

A collaborative ecosystem has the potential to result in cost savings of services and processes. To involve the industry in a collaborative ecosystem, incentives for participate need to be created (Ojasalo and Kauppinen, 2016). As digitalization and IoT has the opportunity to gather big data which can be offered to firms as they can use the data to facilitate customization and development of products (Green et al., 2017; Trabucchi and Buganza, 2019). The academia is also important and according to Wang (2018), firms typically came to academia to gain access to new employees, gain market access or acquire competencies. Not all actors have the same importance regarding decision making, but an effective transformation to smart city requires involvement of all actors and ensuring that the focus is to create benefits for all (Guarneri, 2018; Stone et al., 2018; Valkokari et al., 2017). The involvement of multiple actors from multiple industries in a collaborative ecosystem has shown to create a strategic agency that spreads ideas throughout the ecosystems and mobilizes actors and resources (Leen et al., 2016).

The importance of citizen involvement was highlighted by (Almirall et al., 2016; Kankaala et al., 2018). Smart city development has focused on city infrastructure like connectivity and sensors, but smart city projects are beginning to see the importance of citizen involvement. (Gooch et al., 2018). By engaging the citizens can lay the foundation for uncover more citizens needs and developing solutions for the city. "The more the citizens are enabled to affect the outcomes, the more interested they become in participating" (Ojasalo and Kauppinen, 2016). Livings labs is a measure that involve citizens as collaborators through all stages of the innovation process to co-create city services (Gooch et al., 2018; Westerlund et al., 2018). The close relationship with citizens that smart cities should aim for can be explained by looking at the energy-industry where Koirala et al. (2018) argues that they should aim at turning customers into prosumers, which is a role where they both consume and produce.

However, citizen participation is challenging. Gooch et al. (2018) identified three barriers for citizen participation. (1) Citizen contributions are often wasted if no third party takes action. Without a procedure for citizens to propose ideas while councils and companies does not show the proper commitment might hinder citizen participation. Citizens has varying level of digital competencies and their ideas might (2) be too costly and (3) require specific technical skills that is difficult for them to realize which can make them reluctant in further trying to realize them.

The third dichotomy is regarding the approach chosen to support smart city development, whether it is top-down or bottom-up. The top-down approach focuses on centralization where the city government initiates development and defines the long-term vision while instantiating a strategic governance framework. However, smart city development can also stem from the civil society which is the bottom-up approach. This approach focuses on distribution instead of centralization which requires closer and more direct involvement of citizens (Mora et al., 2019b; Ghanbari et al., 2017). The strength of the top-down approach is in the coordination and control over the development process and drives it forward (Pflaum and Golzer, 2018). However, bottom-up approach are better at identifying and satisfying local and civilian needs (Mora et al., 2019b). There are strengths and weaknesses with both approaches and researchers argue that cities should aim to have a mixed approach as they can have synergistic effects (Haines, 2016; Appio et al., 2018; Ghanbari et al., 2017). An example by Ghanbari et al. (2017) was to develop IoT-solutions with a bottom-up approach that accommodates the local needs while the top-down solutions provide general development frameworks that integrates the solutions.

The last dichotomy is whether cities should choose a mono-dimension vision or a broader integrated intervention logic. As digitalization, as mentioned in 3.2, should be seen as a sociotechnical process, hence a broader focus is the key to develop a sustainable smart city (Mora et al., 2019b).

3.5.1 Open data

Big data has been mentioned several times in this report and that is due to the value it can have for actors. The data can be used in numerous ways to provide competitive advantages and new opportunities as mentioned in section 3.5. "The data generation can be done in various ways, either manually by internal staff, automatically through the use of sensors and tracking tools (e.g. Web-tracking scripts) or using crowd-sourcing tools" (Hartmann et al., 2014). The data generation can By utilizing analytic tools, data mining techniques and business intelligence tools, actors can generate even more knowledge to gain competitive advantages such as new value propositions, effectivizing manufactures, decision making and knowledge of customer behaviour (Urbinati et al., 2018; Sarma and Sunny, 2017).

IoT and smart solutions have the ability to collect data from anything as long as a sensor can be embedded (Klein et al., 2017). To realize the potential of the big data, from section 3.3 and 3.4, a collaborative ecosystem is important to develop. Hakanen and Rajala (2018); Ojasalo and Kauppinen (2016) showed that data sharing throughout the ecosystem to facilitate collaborative value creation can increase the value potential of products. However, they argue that there is a lack of knowledge on incentives for data sharing in ecosystems and trust between actors in the steel industry which hinders participation in ecosystems. Actors need to see data sharing as beneficial for them (Marcelo Iury, 2019).

Ojasalo and Kauppinen (2016) "found cities to receive and store large amounts of data". Open data has been a focus point for cities in the development of smart cities in context of ecosystems. The reasoning behind open data is that provision of data might facilitate innovation and participation of other actors such as citizens, researchers and developers, by making it easier to access, analyze and share (Gooch et al., 2018; Okwechime et al., 2018). The sharing of data can be done through a platform where real-time data can be stored, analyzed and published (Okwechime et al., 2018). However, there are few successful solutions based on open data due to barriers such as inadequate infrastructures (Almirall et al., 2016). On the other hand, the academia, practitioners and public sector has had a growing interest in open data. "New efforts are increasingly being made by government, industry, academia, and even private institutions on ways to convert data for decision-making, and promote the research and development of data science and analytics"(Cao, 2017).

However, with a huge amount of data, privacy might be of concern (Gretzel et al., 2015). Customers might consent to being data generators, but only as long as the perceived value is larger than the perceived costs. Privacy can be a important factor for some customers (Turgut and Boloni, 2017). Collaboration is therefore important as the realization of open data value can only occur in an ecosystem where all actors cooperate Tucci et al. (2018) and the most important role in the ecosystem is the intermediary Papert and Pflaum (2017) or infomediary Tucci et al. (2018) as they are the enablers and facilitators of data and collaboration while ensuring the appropriate information privacy.

3.5.2 Monetizing big data

Developing smart cities are in the focus in many cities, but monetizing is not a frequent mentioned theme. That is because cities tend to focus on qualitative, unmontetized values (Naveed et al., 2018; Watanabe et al., 2018). However, we still believe it is of interest to identify ways of monetizing on big data as the financial aspect are important for many actors in the ecosystem and supports the actors (Valkokari et al., 2017).

As there has been changes in technology, the business models has to change to accommodate the opportunities and examples of new revenue models are mobile payment, pay-per-use, subscription fees, cross selling, freemium, third party revenue model, razor-blade models and targeted internet advertisements (Whitmore et al., 2015; Matzler et al., 2013; Arnold et al., 2017; Parida et al., 2019). However, IoT-ecosystems has taken it further and moved away from the traditional one-off payment approach to the as-a-service (Pflaum and Golzer, 2018).

Urbinati et al. (2018) identified two different innovation service strategies in context of big data, use case-driven and process driven. The strategies differ in three aspects. Ownership over the data can be the customers or the providers, the use of technology can used directly or indirectly and the characteristics of the offer in terms of analytic solution, skills and expertise can differ. As mentioned in subsection 3.5.1, smart cities focusing on open data. The concept of open data is difficult to monetize, however, cities can manage the data and monetize on delivering analytic solutions. This strategy requires cities to focus on data analysis skills (Urbinati et al., 2018).

Four business models relevant for the smart city ecosystem was derived by Brock et al. (2018) by studying Philips lighting. (1) Marbles business model is the simples where there is no value co-creation and everything is individually developed and sold by the business. (2) In the Tetris business models, value is individually created, but the revenue model is embedded with other revenue models in order to share revenues across the ecosystem. (3) The Jenga business model is where value is co-created and the actors try to learn for each other. (4) The last one is the Jigsaw Puzzle business model where value is co-created and co-captured. The business model tries to exploit synergies within the ecosystems in order to maximize value for both customers and the ecosystem.

Cheah and Wang (2017) "argues that big data is a logical final step in virtual value chain". They further describe the monetizing process. The monetizing begins by first collecting data, then storing before applying analytic processes to extract the value.

Data driven business models

Pflaum and Golzer (2018) identified two different strategies at monetizing IoT for businesses. The first is to embed smart solutions into physical products while the second strategy is to use smart solutions to optimize their own processes. The amount of data that can be collected with IoT-solutions can be analyzed to identify new business opportunities and new business models (Brown, 2017; Cheah and Wang, 2017). "data has become a tradable and valuable good" (Marcelo Iury, 2019). Cities can therefore develop business models that focuses on creating value from data and selling data embedded in the smart services (Pflaum and Golzer, 2018).

The type of business model that Pflaum and Golzer (2018) presents is called *data-driven business models*. The factors that needs focus when developing data-driven business models are investing in the appropriate technology, developing technical and managerial skills and create a learning culture within the organization. Collaboration and knowledge of different actors in ecosystems is important 3.3. Pappas et al. (2018) adapts the helix-framework to the big data and business analytics ecosystem. They derive a quintuple helix consisting of (1) Academia, (2) industry/private organizations, (3) government/public organizations, (4) civil society, and (5) individuals/entrepreneurs.

Following digitalization and emergence of IoT, revenue models are being innovated. Apple and Google lead mobile and wearable device ecosystems (Vesselkov et al., 2018). Google are also known for handling big data and an example of them monetizing big data are their revenue model with Google maps. Developers are given a 200$ credit card every month to be used for developing, thus giving developers access to the APIs without charge. After the credit card has been emptied, the developers has to pay for further usage (Google, nd).

The smart cities are able to facilitate various business models following the anything-as-a-service approach. Examples are cloud-based business models, infrastructure-as-a-service, platform-as a service, sensing-as-a-service, analytics-as-service, data-as-a-service and software-as-a-service (Hartmann et al., 2014). The benefits of the anything-as-a-service approach is that it reduces the financial barrier that hinder small and medium business as they do not need to pay for the ownership, but only the service (Pflaum and Golzer, 2018). Section 3.4 as well as 3.3 mentioned the platform model and we will focus on that model.

3.5.3 Platform based business models

The smart city development has created better flow of data and platforms to host the data. From subsection 3.3, Leminen et al. (2018) identified the platform business model where a dominant actors provides a platform to provide services from other actors thus taking the role as a service integrator. The importance of platforms, such as social networks and smartphone app stores, are rapidly increasing (de Reuver et al., 2018). However, data can also be held in platforms and made available within and across firms. The data can then be used by other actors to secure competitive advantages such as platforms hosting customer information can "create new business opportunities, improving marketing, customer relationship management (CRM) and business strategy" (Stone et al., 2017).

A business model for sensor-based services was proposed by Guijarro et al. (2019) where a platform creates a multi-sided market. The platform serves as a intermediary between users, developers and sensor networks and gathers the data from the sensor network, and the developers make use of the data for developing solutions for the users to use (Shaughnessy, 2016). The platform can further be developed to provide an infrastructure that enables other actors to self-integrate their resources. Having the leading platform makes actors want to be on the platform as they want market access(Hein et al., 2019). By being the developer or owner of a platform, a benefit is that data protection regulation may be managed centrally (Stone et al., 2017). However, platform competition can arise. In that case customers has to not only identify their competitors, but also how they can participate in other ecosystems so that they will not be left behind (Sussan and Acs, 2017). To monetize the platform, a fee can be posted for each of the sides to maximize profit, or one can utilize the revenue models mentioned above. As platform models are inherently dependent on ecosystems, platform owner has create a money flow throughout the ecosystem to motivate actors to join the platform (Shaughnessy, 2016).

3.5.4 Access based business models

Another type of business models that has gotten more interest is the access based based business model. The traditional modes of acquisition and consumption are replaced by enabling access to resources through either sharing or pooling. Access based consumption is therefore defined as a type of transaction that is mediated by the market where consumers acquire consumption time instead of ownership. This lessens constraints, such as financial constraints and burdens of ownership, that hinder consumers in choosing services (Bardhi and M. Eckhardt, 2012). An example is mobility sharing that has been developed (Wiprächtiger et al., 2019).

4 Digitalization in the public sector

The public sector is becoming aware that factors such as urbanization, aging populations, and a more demanding climate are more relevant than ever (Sintef, 2018). With a limited number of resources, municipalities need to take action to not be left behind by the digital revolution. It is estimated that the digitalization of Norwegian municipalities have a total benefit realization of over 100 billion NOK the next ten years while the most optimistic estimation is 250 billion NOK with healthcare as the most promising sector (Mellbye and Gierloff, 2018). However, they must prioritize and act quickly in order to realize these opportunities.

4.1 Norway

The Norwegian government presented a statement regarding digitalization called *Digital agenda for Norway* (Regjeringen, 2015). The ICT policy has two main goals, (1) user-oriented development and effective public administration, and (2) Value creation and participation for everyone. The municipalities are to follow the statement and most digitalization strategies. Five main priorities are stated in the statement. (1) Users, such as citizens, public and private organizations and the voluntary sector, is in centre, (2) ICT is a significant input factor for innovation and productivity, (3) enhanced digital competence and participation, (4) effective digitization of the public sector and (5) good privacy and good information security. To implement the statement, the government has given increased responsibility to Difi and KS [1].

According to Mellbye and Gierloff (2018), more than 230 digitalization project was identified in Norwegian municipalities. In the last year, more municipalities are expecting benefits from digitalization and the improvement of service portofolio is a value they believe in (Evry, 2017). However, a survey by Statistics Norway regarding ICT-usage in firms revealed that it is the larger firms that are most progressive in ICT-usage, while the usage of quick network risen steadly the last years

[1] Norwegian Association of Local and Regional Authorities

(Dyngen, 2015; SSB, 2018). In society, Norway has a leading position in internet access per household (97%) (Eurostat, 2018).

From Rambøll (2018), smart city development is done in clusters in Norway. The characteristics of the municipalities that has reached the furthest in smart city development are the larger municipalities. In the west, 17 municipalities are participating in project *Greater Stavanger* and its sub-projects such as *The smart municipality project*[2], *Stavanger smart region*. Stavanger is the focal municipality for the regional smart city development. In the east, multiple municipalities are participating in *Smart Innovation Norway* which is a collaborative constellation. In mid-Norway, Kristiansund, Stjørdal and Trondheim has taken major steps in smart city development. Trondheim and NTNU [3] are collaborating and the municipality participates in Horizon2020 financed collaborative program for smart and energi-sustainable cities. In the north, Bodøare collaborating with Nordland county municipality, Forskningsrẹt, Nord university, NHO and more to be the national pilot-city in context of interlligent transportation systems.

Few municipalities are developing smart cities alone. Both public and private actors are involved through national initiatives such as Smart Cities Norway. The smart city initiatives are often based on mutual learning between municipalities, complimentary competencies and shared resources (Rambøll, 2018). There are several drivers for smart city development. In Norway, urbanization and the ageing population are usual mentioned drivers. However, most municipalities (71%) wishes to provide a attractive service portifolio to the citizens while 65% wants to use smart city development to attract new citizens (Rambøll, 2018). Smaller municipalities are struggling with population and many has a negative population growth even though Norway had a population growth of 0.6% (KS, 2019).

However, barriers regarding to benefits realization were highlighted by Mellbye and Gierloff (2018). They list lack of competencies and the will to change, and minimal use of shared solutions and open standards. They argue that these challenges are a bigger problem than the ICT-systems. However, the development is going in the right direction. The increase use of ICT contributed to approximately 30% of all production growth in the norwegian economy. Sintef (2018) lists several technologies that are important to achieve digitalization and big data, sensors and connectivity are some of the mentioned ones.

[2]Translated from norwegian: Smartkommune-prosjektet
[3]Norwegian University of Science and Technology

4.2 Sweden

In 2018, Visma claimed that Swedish firms were superior to Norwegian firms regarding digitalization (Falck-Ytter, 2018). However, such comparisons are yet to be made for digitalization within the public sector. Many swedes are becoming aware of new forms of collaboration between cities, business, academia, research institutes and civil society, and organizations and programs have started to form. One strategic innovation program is called Viable Cities, with the primary goal of contributing to research and innovation in the area of smart, sustainable cities. The time frame is 2017 to 2029, and the host organization is KTH Royal Institute of Technology in Stockholm. The program receives support from Sweden's Innovation Agency (Vinnova), the Swedish Research Council of Sustainable Development (Formas), and the Swedish Energy Agency, which is also the supervising authority (ViableCities, 2018a). The program was initiated as part of efforts to achieve Swedish energy and climate goals, and provide a stronger foundation for sustainable growth. Viable Cities aim to be a catalyst for helping to develop and utilize innovation and knowledge for smart, sustainable cities.

A recent research project that has received support from Viable Cities is the *Coordinated infrastructure for smart and sustainable small cities* (SAMIR), which is Led by Björn Laumert and Jan Markendahl from KTH. The project aims to explore needs for and limitations in small municipalities using digitalization and smart solutions for coordinated infrastructure. In addition, the project will explore possibilities of using the local fibre networks as a backbone for the digitalization of water, sewage and electricity, but also other municipal/regional operations such as lighting, parking and public transit (ViableCities, 2018b). Herrljunga and Kungälvs municipalities are both partners, together with their respective energy companies and fibre network providers. ServaNet runs local fibre networks in several municipalities in Northern Sweden, and is also included in the project.

According to Claesson et al. (2019), a majority of their researched municipalities cooperated with other municipalities, and had been doing so for numerous years. Between the municipalities, there are opportunities to utilize common IT strategies and coordinate procurement. There is often cooperation and coordination between municipal enterprises and the municipality itself, while it is more unusual between private firms and the municipality. When it comes to collaboration within the municipality, there are opportunities related to common communication and technology platforms, as well as the collective organization of operations. However, certain municipalities consider it difficult to share the operative department as there are variations between activities and a need for local presence.

It is also found that problems and obstacles are not primarily technical, but stem from inadequate organization, coordination and the lack of communication between different municipal activities and administrations (Claesson et al., 2019). One example is that energy, electricity and networks can be split and organized through different firms. Otherwise, there could be lack of cooperation and governance within the municipality itself. There are also municipalities with separate ordering- and delivery functions for IT, which can mean that collaboration and development opportunities are missed. In certain cases, there are procurement rules that entail a lack of cooperation between the municipality and its enterprises. This can lead to situations where the municipality and the companies must spend resources to buy services that the municipality's own companies could have provided.

As part of the SAMIR project, Andersson et al. (2019) have written a report on the current situation, plans and conditions for digitalizing infrastructure in smaller municipalities. Characteristics such as geography, population and density, socio-economic composition, infrastructure ownership and municipal governance are analysed behalf on how they can affect the choice of ICT and IoT solutions for the municipality's services and infrastructure. Neither for smaller municipalities are the barriers and challenges for digitalization mainly technical, but depend on organization and tradition (Andersson et al., 2019).

The findings suggested three main patterns: (1) Diversity of different systems and system types, as well as lack of integration require both broader competence and more time to process and operate. It is also difficult to upscale or expand, (2) Lack of knowledge of both existing and future systems and IT competence prevents municipalities from acting. There may be a risk of becoming dependent on suppliers. (3) Often, problems are related to difficulties in changing working methods and activities. Thus, innovative measures and new technology often meet resistance. However, these challenges can also be identified in large municipalities. Although many believe that lack of knowledge or competencies is primarily a problem for smaller municipalities, there are several examples of smaller municipalities that are far ahead and have very high awareness of problems and possible solutions (Andersson et al., 2019).

5 Article

Digitalization of Municipalities Through Ecosystem Cooperation

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Abstract

Emerging technologies combined with new ways of doing business provides a series of new possibilities, but also significant challenges. In this paper, we analyze how municipalities can realize value from digitalization through ecosystem cooperation. Building on recent literature regarding emerging technologies, ecosystems and digitalization in the public sector, we analyze 26 digitalization strategies that represent 58 municipalities to get an overlook of the current landscape. Meanwhile, we utilize in-depth interviews with five case studies of municipalities that are further ahead, to discover cross-case similarities and patterns. Our findings highlight important strategic measures related to different types of value for the majority of municipal digitalization approaches. We also find experimentation, IoT-solutions and innovative approaches among the case study municipalities that are further ahead. The results are thoroughly analyzed and discussed towards recent literature and international research on the digitalization of comparable municipalities.

Keywords: Digitalization, Ecosystem, Public Sector, Value, Cooperation, Municipality, Internet of Things, Business Network

1. Introduction

In today's modern society, digitization is relevant in all sectors and industries. There is an exponential growth of available data, with an embedded value potential that could be commercialized or monetized (Hartmann et al., 2014). Meanwhile, the public sector is becoming aware that factors such as urbanization, aging populations, and a more demanding climate are more relevant than ever (Sintef, 2018). With a limited amount of resources, municipalities need to take action to not be left behind by the digital revolution. It is estimated that the digitalization of Norwegian municipalities have a total benefit realization of over 100 BNOK the next ten years (Mellbye & Gierloff, 2018). However, they must prioritize and act quickly in order to realize these opportunities.

Over the last decade, the Internet of Things (IoT) have been in a continuous state of evolution. IoT is often defined as the interconnection of physical objects by equipping them with sensors, actuators and means to connect them to the Internet (Dijkman et al., 2015). IoT technologies is a key driver of the digital transformation that will enable businesses to reinvent products, services, internal operations and business models (Twentyman, 2017). The combined markets of the IoT are forecasted to grow to about $520 billion in 2021, more than double the $235 billion spent in 2017 (Bosche et al., 2018). The application of the technology is vast and has the potential to drive the next steps of the digitization of our society and economy. Firms have already begun to embrace the IoT and the public sector is following the trend.

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Digitalization enables new types of solutions that are more flexible and effective. In the context of municipalities, the use of IoT technologies are often linked to the development of smarter cities.The public sector as a whole is playing a major role in the IoT market around smart city initiatives, and drives the demand for IoT-solutions (Aguzzi et al., 2014). Examples of initiatives taken are smarter utilization and deployment of public resources such as lights, roads and parking, better efficiency of services like waste management and public transportation, and better quality of life such as measurement of pollution (Furini et al., 2018). The public sector influences the overall IoT ecosystem by providing continuous stimulus, financial resources and raising the awareness of the IoT (Aguzzi et al., 2014).

In 2015, the Norwegian government published a white paper called *Digital Agenda Norway*. It highlights five areas that should be prioritized in Norwegian ICT-politics: the user in centre, ICT is important for innovation and productivity, strengthened digital competences and participation, effective digitalization of the public sector, good privacy and information security (Government, 2015). A conceptualization of municipal digitalization is the development of smart cities, which can be defined in the following manner: *A smart city uses digital technology to make the cities better places to live and work. It aims to improve public services and the life quality of the residents, optimally utilize common resources, increase productivity, and reduce climate and environmental issues in the city* (Government, 2015).

Although the terms digitalization and smart city development is often used interchangeably in public, smart city development can be seen as a branch of the digitalization of the municipality. Some municipalities have smart city programs, while other does not. It is found that smart cities can generate value by liming the internal spending within municipalities (Schiavone et al., 2018). Although not compulsory, smart city development is often a substantial part of a municipality's digitalization process. Many municipalities seem to undertake projects inspired by smart cities, without specifically calling it a smart city initiative (AgendaKaupang, 2018).

The global issues we are facing as a society are large and extensive, and can not be solved without cooperation across all sectors of our community (Sintef, 2018). Emerging technologies with relation to connectivity, use of sensors and collection of data also make digitalization stretch across municipal boundaries. Different resources and competences from several fields are needed, which makes the process of value creation move from the perspective of a single firm to the perspective of an ecosystem consisting of many (Laya et al., 2018). Research on ecosystems will therefore be used to understand how municipalities cooperate with other actors in order to create value from digitalization.

Municipalities rarely use the term business models when discussing strategies and plans. However, the term benefit realization management is commonly used. It has numerous different interpretations, but is often comparable to business opportunity (Zott et al., 2011). With the emergence of IoT and digital technologies, managers should turn their focus from business models to ecosystems (Westerlund et al., 2014; Laya et al., 2018). It is through a business model that accounts for the surrounding inter-organizational network and collaborating partners, that organizations can generate greater opportunities for improved service delivery, distribution of risks (Parida & Wincent, 2019).

Although smart products are at the core of digital solutions, in most cases the full applications require complementary innovations such as cloud and mobile computing, digital social networks and data analytics. The combination of different technologies drive the IoT development and creates the possibility of data-driven services (Pflaum & Golzer, 2018). Pflaum & Golzer (2018) presents two strategies from the private sector where one is to embed IoT-technology in a physical product and turn it into a smart service, while the other one is to implement IoT-solutions to increase efficiency of production processes. However, the data generated from IoT-solutions can be sold, but this leads to several questions: How can public data be monetized, who owns the data and how can one differentiate between data and services when the data is available for everyone? Financial value is not necessarily the only type of benefit realization that is desirable for municipalities, and we would therefore like to investigate what they propose as the main goal value of digitalization. This leads us to the following research question:

Research question: How can municipalities realize value from digitalization through ecosystem cooperation?

We will collect empirical material on Norwegian municipalities in order to research this topic. Through a pool of ongoing digitalization strategies together with a selection of in-depth case studies by municipalities we aim to present the current practices, and important challenges. The findings will be based on how the municipalities cooperate with the actors in their ecosystem, with regards to different types of realized value. A common topic in business development literature from the ecosystem perspective is value co-creation and cooperation. We will also investigate which type of value is the most emphasized by the municipalities, and what quantitative and qualitative benefits are mentioned frequently. The main contribution of this paper is a mapping of the current practices regarding the digitalization of municipalities. A broad basis of digitalization strategies will allow us to investigate current practices, while five case studies allow us to go in depth.

The rest of the paper is organized as follows: the theoretical background is presented in the next section, followed by the research design method including the data collection, selection of case studies, and the data analysis process. Then, the findings from a basis of digitalization strategies, followed by an in-depth presentation of five case studies will be presented. This is used as a basis for an analysis of the findings, including cross-case comparison of the case studies. It will then be thoroughly discussed with regards to the theoretical basis and other research done in the field of digitalization in municipalities. The last section will present the conclusions, limitations, and managerial implications of this research.

2. Literature Review

In recent literature, there have been various papers discussing the business model and development aspects of digital solutions (Faissal Bassis & Armellini, 2018; Parida et al., 2019; Leminen et al., 2018; Westerlund et al., 2014). Business models are the framework often used by business to analyze how they can exploit business opportunities and describe how they do business (Zott et al., 2011). The common notion in the emerging literature of business models related to IoT is the focus on ecosystem and environment. As digital ecosystems often span over multiple industries, businesses are required to cooperate (Leminen et al., 2018). A single IoT-solution provide little value, but when combined into complex digital innovations with many building blocks, the full value is realized (Klein et al., 2017). Therefore, the implementation of IoT relies heavily on the ecosystems across different industries (Andersson & Mattsson, 2015). A single actor is less likely able to deliver complete IoT-solutions, and resources and competencies from different fields are required (Ghanbari et al., 2017). Traditionally, innovation has often happened in closed context in businesses. The older frameworks are often focused on the firm-level and typically observe the network through the firm's perspective (Ghanbari et al., 2017). Westerlund et al. (2014) describes the IoT ecosystems as unstructured where actors are struggling to identify the roles of themselves and other actors.

Mora et al. (2019a) identified five diverging development paths for smart cities, that they used to derive four dichotomies that challenges smart city development: (1) technology-led or holistic strategy, (2) helix model of collaboration, (3) top-down or bottom-up approach, and (4) mono-dimensional or integrated intervention logic. The first dichotomy is regarding if cities should focus on technology development to facilitate the smart city development or if they should approach holistically and try to align the technology to the human, social, cultural, economic and environmental factors (Mora et al., 2019b). Appio et al. (2018) identified several arguments for the idea that smart cities should move towards a holistic strategy. Westerlund et al. (2014) presented the concept of value networks as a model to emphasize the holistic focus on value creation rather than individual firms delivering isolated solutions. Value nodes and value exchanges describes the actors and activities that link to others, and the exchange of value such as knowledge and information. Several scholars agree that smart city development takes place in a collaborative ecosystem where the interactions and feedback between the actors facilitate development (Leydesdorff & Deakin, 2011; Gardner & Hespanhol, 2018; van Waart et al., 2016).

The cooperation between actors are often, in the context of digitalization and smart city development, described using the helix framework. There are various versions of this framework, depending on the number of different actor categories focused on. The triple helix model focuses on the interaction of the state, academia, and industry (Carayannis, 2019). Here, the state represents the government sector, academia the higher education sector, and industry the business enterprise sector. Adding to the triple helix, *the public* or *society*, can be introduced to obtain a quadruple helix model. This fourth helix associates with media, creative industries, culture, values, and life styles. A quadruple helix model with digitalization of municipalities in center is shown in Figure 1. Lastly, the quintuple helix is where the *environment* or the *natural environments* represent the fifth helix (Carayannis, 2019). The idea behind the quintuple helix model is that the implementation of thought and action in sustainability will have a positive impact on society as a whole.

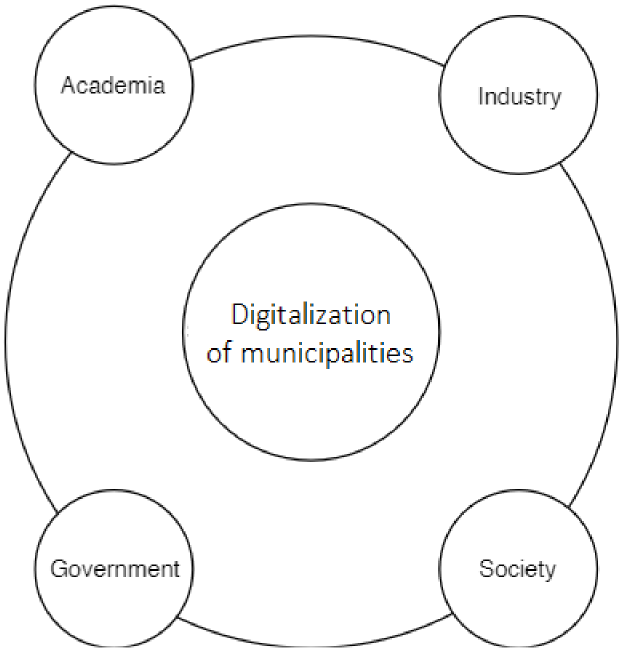

Figure 1: Theoretical framework - quadruple helix model with digitalization of municipalities in center

Regarding the third dichotomy by Mora et al. (2019a), the top-down approach has been criticized by Shin (2007), who argue that the approach fails to look after the civilian needs. Capdevila & Zarlenga (2015) argues the top-down and bottom-up approaches do not necessarily work against each-other, but can benefit from each other. By combining the two approaches, municipalities can for example create IoT-solutions with a bottom-up approach to address identified and local needs, while the government develop open innovation platforms to combine and facilitate the bottom-up solutions (Ghanbari et al., 2017; Ojasalo & Kauppinen, 2016). Furthermore, to support bottom-up development, many smart cities have been promoting open data (Okwechime et al., 2018). However, the current IoT ecosystem is highly fragmented with many similar solutions that uses different infrastructures that might hinder collaboration (Laya et al., 2018). The fourth and last dichotomy by Mora et al. (2019a) says that when developing goals, actors can choose between mono-dimensional (narrow) or integrated (broad) intervention logic.

Pflaum & Golzer (2018) identified two different strategies at monetizing IoT. The first is to embed smart solutions into physical products, while the second strategy is to use smart solutions to optimize their own processes. The amount of data that can be collected with IoT-solutions can be analyzed to identify new business opportunities and new business models (Brown, 2017; Cheah & Wang, 2017). Pflaum & Golzer (2018) derived a new, data-driven business model that focused on collecting, analyzing and selling data. However, Okwechime et al. (2018) argue that big data loses its value if the organizations lack the competencies to embed the knowledge. Furthermore, scholars argue that there are incentives for the industry to buy and have access to the big data. Examples of opportunities that big data provides for companies are that it can be used to determine market demand, reduce costs, identify new business opportunities and business models (Cheah & Wang, 2017).

Monetizing is not frequently mentioned in digitalization research, and that is because cities tend to focus on qualitative, un-montetized values (Naveed et al., 2018; Watanabe et al., 2018). As there has been changes in technology, the business models has to change to accommodate the opportunities and examples of new revenue models are mobile payment, pay-per-use, subscription fees, cross selling, freemium, third party revenue model, razor-blade models and targeted internet advertisements (Whitmore et al., 2015; Matzler et al., 2013; Arnold et al., 2017; Parida et al., 2019). However, IoT-ecosystems has taken it further and moved away from the traditional one-off payment approach to the as-a-service (Pflaum & Golzer, 2018). An example of a data-driven business model is Google who is known for handling big data. An example is their revenue model for Google Maps. Developers are given a 200$ credit card every month to be used for developing, thus giving developers access to the APIs without charge. After the credit card has been emptied, the developers have to pay for further usage (Google, 2019). Data can also be held in platforms and made available within and across firms (Stone et al., 2017). Leminen et al. (2018) identified the platform business model where a dominant actors provides a platform to provide services from other actors, thus taking the role as a service integrator.

3. Methodology

3.1. Data collection

In order to explore the existing theoretical basis on digitalization, value and cooperation in an ecosystem, we conducted a systematic literature search. The aim was to understand conceptual categories and their properties, developed from the empirical evidence of comparative studies (Wagner et al., 1968). This primary round of data collection was carried out before refining the research question, and provided us with the broad theoretical basis for this paper. The aim was to enhance the legitimacy and authority of the resultant evidence, to provide a reliable basis to formulate decisions and take action (Tranfield et al., 2003). Afterwards, this basis was supplemented with relevant research cited by the selected authors, as well as separate searches for specific concepts. The empirical material is composed of a combination of primary and secondary data, found in Table 1.

Data source	Description	Informants and authors
Digitalization strategies	26 strategies representing 58 municipalities 2 steering documents including guidelines on digitalization	Municipal council IT-department Councilman County council Municipal council IT-department
Interviews	4 interviews with 7 informants from 4 municipalities, conducted by Telenor 1 interview with 1 informant from a region consisting of six municipalities, conducted by us	Innovation- and smart city department leaders IT-department advisors and leaders Leader of cooperative region data department
Documents	Industry level reports on the dynamics of the industry Reports from the national and regional authorities Status reports from digital consultancy firms Project reports from Swedish digitalization research	International smart city organizations National industry leaders Norwegian government Norwegian association of local and regional authorities Technological consultancy firms Economic consultancy firms Project leaders Researchers from international universities
Statistical data	Statistical data on municipalities	Statistics Norway (ssb.no)

Table 1: Overview of empirical data sources

The selected digitalization strategies need to be ongoing and current, thus outdated strategies are not chosen. Certain municipalities cooperate with others in the digitalization process, so the total number of involved municipalities is higher than the number of strategies. The chosen strategies are independent with a main focus on digitalization. We did not consider municipalities that only include sections about digitalization incorporated in other municipal plans, in order for the strategies to be as comparable as possible. In order to discuss and compare the findings to recent research on the digitalization of small municipalities in Sweden, we chose digitalization strategies with the intended representation of a majority of small- and medium sized municipalities in mind.

3.2. Case study selection

Our strategy is a multiple-case design research, with a basis of five real-life cases. The aim is that these cases can provide a great deal of largely qualitative data, which can offer insights into the nature of the phenomena (Easton, 2010). Each of the case studies describe how the municipality and its network of actors strategize in order to digitalize, with regards to different dimensions that will be explained in section 3.3.

The five case municipalities are chosen because they are considered relatively far ahead in the process of digitalization compared to other municipalities, a form of purposive theoretical sampling (Easton, 2010). This evaluation was done by having all case studies fulfill three chosen demands: (1) The municipality needs an adopted plan or strategic paper regarding digitalization or smart city development, (2) There needs to be ongoing or finished digitalization projects, and (3) There needs to be some formal or informal cooperation with other municipalities.

The background for demand (1) resonates with the municipalities being dedicated to digitalization, and the awareness that the terms digitalization and smart city development are often used interchangeably by the public. Although smart city initiatives are only a subsection of the overall digitalization, an active smart city initiative is most often a good indication on the efforts dedicated to digitalization (Rambøll, 2018). Given that only 30-50 of the over 400 municipalities have active smart city initiatives (AgendaKaupang, 2018; Kartverket, 2019) it is logical to consider these municipalities relatively far ahead compared to the national average. Demand (2) allows us to get practical insights into the measures carried out to digitalize, and the possible results. Lastly (3) is crucial in order to understand the ecosystem perspective and the cooperation between actors.

In addition, the case studies have been purposely chosen to reflect different sized municipalities of several geographic areas, in order to more accurately represent the data (Hsieh & Shannon, 2005). In this case, no more than two municipalities from the same county were chosen, given the focus of independently analyzing actors in their ecosystem. In this way, the case studies can be seen as comparable to each other but also previous research. Some structural similarities may occur due to this purposive theoretical sampling of municipalities. However, the implementations of the digitalization measures differ in practice, and thus we choose to go in depth on this topic. The case studies will be anonymous, as we address information such as challenges and classified information.

The fifth and last case study (Epsilon) somewhat differs from the other four. It is not an individual municipality, but a region consisting of six small municipalities that cooperate with regards to digitalization. The reason we were interested in this particular case study is to gain insight on how a formal cooperation works in practice. The municipalities in this region are also significantly smaller than the other four case study municipalities, and we are curious whether this has an impact on any of the factors. As a whole, the region also fulfills the above mentioned three demands.

3.3. Data analysis

The objective of the data analysis is to find how municipalities can realize value from digitalization, with respect to solutions that include ecosystem cooperation.

Digitalization strategies. We have chosen content analysis, which is usually appropriate when existing theory or research literature on a phenomenon is limited (Hsieh & Shannon, 2005). We therefore start making observations that lead us to a preliminary data organization and data analysis. We have used NVivo to organize and group data into meaningful codes, in order to obtain a series of smaller categories to base the findings around (Hsieh & Shannon, 2005). This was done by using open and selective coding.

Both authors analyzed the digitalization strategies independently, and followed the same steps. First, open coding was conducted by analyzing every sentence of the digitalization reports line-by-line. With regards to the research question and the nature of the digitalization strategies, we defined conceptual content as data that fit under five chosen clusters: Actors, development focus area, core strategic topic, and perceived value. In the first step, all conceptual content was marked important. Then, we used focused coding to synthesize the content into conceptual labels (NVivo codes) as close to the transcript as possible. Lastly, we saw that certain conceptual codes were subcategories under a common topic, thus these were merged together and categorized under a new parent code. This reduced the total number of codes and made the findings more usable and readable (Hsieh & Shannon, 2005). An example of the full open coding process can be found in Appendix A.2.

Case studies. Then, five case studies will be analyzed with respect to the focus areas and relevant technologies for the digitalization within municipalities, as well as how the network of actors within the ecosystem is built up and whether there is cooperation towards a common goal. The case municipalities were interviewed using the same procedure and documented to ensure reproucibility. The interview guide can be found in Appendix A.1.

The chosen approach starts with within-case analysis, which involves detailed case study write-ups for each site. These write-ups are simply pure descriptions, but they are central to the generation of insight (Eisenhardt, 1989). The aim is to discover the unique patterns of each case, before generalizing patterns across cases. Thus, the next step is searching for cross-case patterns, to force investigators to go beyond initial impressions, especially through the use of structured and diverse lenses on the data (Eisenhardt, 1989). Our chosen approach is to select four dimensions, and then look for within-group similarities coupled with intergroup differences. The dimensions are: General description of focus areas, current projects, actors within the ecosystem, and challenges. Together, they should create a basis to analyze the current state of the digitalization process within each of the case studies.

4. Findings

In this section, we first present the findings from 26 digitalization strategies by 58 municipalities. Central patterns within the municipalities' development focus areas, core strategic topics and different conceptualizations of value are found and categorized. The ecosystem actors in which the municipality operates are also presented. Second, we present five case studies where we go in-depth with each municipality in center. Every case description is divided into four parts: a general description, a summary of current digitalization projects, actors within the ecosystem, and challenges related to this process. These findings will be summarized and together serve as a basis for the following analysis and cross-case comparison.

4.1. Findings from digitalization strategies

Table 2 summarize the most frequent categorizations within each cluster. Naturally, the municipality itself was the most heavily mentioned public actor in the ecosystem, but public instances on a county- and national basis were also found. Many municipalities have user-centered approaches, and thus society is coded numerous times. Residents, especially elderly and children is highlighted. Governmental actors such as national and international jurisdiction, guidelines and legislation are moderately mentioned, as well as industry in the form of service providers, partners and suppliers. Lastly, academia is only mentioned in three of the digitalization strategies, which is significantly lower than the other ecosystem actors.

In this case, the most frequent development focus areas are both in the form of traditional sectors such as health care and education, and challenge areas such as security and privacy and ICT infrastructure. Information security and privacy are the most common conceptualizations, next to architecture, platforms and network infrastructure. There were also more traditional municipal focus areas such as hospital technologies, retirement facilities and patient interactions. In the educational sector, digital learning tools and cloud solutions were heavily mentioned. In the other end of the scale, there was single digit number of instances covering house and buildings as well as greener environment.

Ecosystem Actors	Development Focus Area	Core Strategic Topic	Value	
	Security and privacy			Service quality
Public actors	ICT-infrastructure	Cooperation, sharing		Usability
	Health care	and involvement	Qualitative	Reliability
Society	Education	Automated processes		User satisfaction
	Welfare technology	Leadership and competencies		Municipal attractivity
Government	Communication and information	Self-service and usability		
	Administration	Evaluation and revision		Productivity
Industry	Area and mobility	Change and innovation	Quantitative	Resource management
	Greener environment	Wholesome solutions		Cost savings
Academia	House and building			Automated processes

Table 2: Summarized findings from digitalization strategies - the most common categorizations

The core strategic topics can be seen as the measures that are needed to be implemented when digitalizing the development focus areas. Both cooperation, sharing and involvement, and automated processes were heavily mentioned, but the first category have a large number of conceptualizations and is coded almost twice as many times as the second. Sharing technology, open data, cooperation between municipalities and resident involvement are currently the hottest topics, and many municipalities believe they have crucial roles in successful digitalization. Leadership and competencies is also a noticeably large factor, where leader training and organizational development are the most common conceptualizations.

Lastly, most municipalities mention both qualitative and quantitative value as goals in the respective digitalization strategies. However, the number of different conceptualizations and instances found are measurably higher for qualitative value. The quantitative goals are mainly based around increase in productivity and efficiency, resource management, cost savings and automated processes. The qualitative value spans wider and reaches from service quality, sustainability, user satisfaction, innovation, and usability, to municipal attractiveness. The full list of conceptualizations can be found in Appendix A.2

4.2. Findings from case studies

This section will summarize the main takeaways from each of the five case studies. The first four case studies are municipalities that can be seen as further ahead than the country average with regards to digitalization. The fifth case study, Epsilon, is a cooperation between six small municipalities towards the digitalization of the region. The complete findings from the case studies can be found in A.3.

Alpha has a high number of implemented projects, and have achieved international recognition for their digitalization efforts. They also collaborate with international partners, as well as academia, enterprise partners and other municipalities. They have a smart city program where the goal is to facilitate development, research and innovation for sustainable community development. The municipality holds workshops and meetings for a series of different actors to initiate interest, innovation and idea-creation in the region. They also participate in county- and nation wide projects to facilitate digital solutions for the residents. Involvement of the public is highlighted in their strategy paper, and Alpha has focus on open data so that anyone are able to create new services. Alpha is also a part of an international network for creating and shaping smart city data. The main challenges for the ongoing digitalization is economy, operations and providing services. The IT-office further argues that it is difficult to buy modular solutions, and that the current solution contributes to a lock-in effect given lack of will to cooperate. They are also challenged externally by the merging of several neighboring municipalities into a new region, with all the administrative changes it will entail.

Beta sees the main goal of digitalization as the increase in efficiency, and highlights that a 10% increase will result in a benefit realization of billions of NOK. They also present qualitative value goals, such as the municipality being a better place to live, where self-service solutions are especially valuable. The infrastructure itself will not provide measurable value, it is the future services that are based on the infrastructure that will realize value. However, they mention a series of obstacles such as limited resources, unwillingness to change, and lacking competencies. Meanwhile, administration and scaling of large systems with many sensors represent data issues and legal challenges. The municipality cooperates with other municipalities regarding projects related to welfare technology. They are also involved with research facilities such as universities and health innovation centres. Within the municipality, they have multiple ongoing sensor-related projects, collect and utilize data, and experiment with LoRaWAN. They have focus on engaging the residents, and provide a public information system about their digitalization projects in the city centre, and provide open WiFi.

Gamma aims to be the most innovative municipality in Norway, and their digitalization program is focused towards cost reduction, providing services and improving the environment. Meanwhile, they highlight the importance of facilitating innovation and creating workplaces. The aim is to achieve this by providing services and data to potential start-up firms. There are several projects, where most are focused on collecting real-time data to increase efficiency of services. The ICT-department is small, thus Gamma is looking to buy rather than develop in-house to attain competence and services. There is communication with other municipalities, but often without a formal structure and many decisions are based on coincidences. Although learning from other municipalities, there is no formal structure or procedures regarding cooperating on digitalization. There are challenges related to data formats not being standardized, and that they have no internal programming competences.

Delta aims to improve the environment, increase inflow of citizens, facilitate academia and research, and be attractive for the industry. They cooperate with four other municipalities with regards to ICT and digitalization, but do experience some problems related to communicating with each other. A lack of common infrastructure leads to different definitions and terminology, and data is deleted after 30 days. There are also issues related to sensitive information and network coverage. They have a smart city program, which is said to have a socio-economic value perspective rather than a quantitative. The success criteria are related to making the region a better place to live. This focus can be observed through the ongoing digitalization projects, which can be said to have a welfare focus. The municipality takes part in innovational partnerships financed by Innovation Norway, and wishes to cooperate with suppliers, residents and the private sector. Currently, a pilot project is underway where possible future partnerships and business models will be evaluated.

Epsilon highlights that the cooperation regarding digitalization has been positive for the overall digitalization in each of the municipalities. However, there are challenges related to all of the municipalities not being as involved or timely focused regarding common plans and goals for the digitalization of the region. There are different emphasis on what a collaboration entails and how it should be carried out, and some municipalities show less initiative. The goal is to provide new digital solutions to the residents, and achieve an increased level of efficiency. However, there are no explicit quantitative goals regarding economic benefits. Cooperates with academia, political organizations and is involved with Innovation Norway. Does not cooperate directly with the private sector regarding innovation, but uses private actors as suppliers for applications and other services. Main challenges are related to limited financial resources and decline in the population.

5. Analysis and cross-case comparison

5.1. Digitalization strategies

Regarding cooperation in the ecosystem, it is difficult to classify the most common helix without going in-depth on each of the municipalities. Generalizing is also associated with risk, as there may be significant differences between each municipality. However, we note that only four out of the 26 digitalization strategies mention the environment or sustainability, which implies that no more than 15% utilize the quintuple helix. We do note that society is frequently mentioned, although often in terms of being the end users as opposed to being involved in the development or innovation process. Media and culture-based approaches are rarely mentioned, thus it is logical to assume the majority of municipalities utilize a triple helix model. However, it must not be excluded that certain municipalities could utilize the quadruple helix.

The findings from the digitalization strategies show a broad focus that span over various areas. Digitalization needs to be shaped with the socio-economic and cultural background in mind, and the selection of applications depends on the local context factors (Neirotti et al., 2014). Many of these factors include urban challenges which are not always related to the singular development focus area. The relatively even distribution of codes presented in Table A.2 suggest that the majority of municipalities are likely to have an integrated intervention logic. We note that in addition to the traditional sectors, several technological challenges are pointed out as focus areas within the digitalization strategies. Indicating that security, privacy and infrastructure are the most urgent focus areas to address, it implies that the majority of the municipalities seem to be technology-led. This is because strategies seem to be based on a massive input of technological solutions in the urban environment. However, we find that many municipalities have a focus on creating a common infrastructure, as well as competencies, revision and change. It is thus likely that certain municipalities tend towards a holistic strategy, rather than solely implementing ICT solutions for the sake of it.

Most municipalities have a measurable focus on realizing qualitative value, although quantitative value is also represented. The economic values are focused on effective resource management, cost savings and better utilization of resources, but the strategies rarely provide guidelines for monetizing the solutions. Given that cooperation, sharing and involvement is the most heavily mentioned core strategic topic, it is likely that many municipalities wish to pursue a bottom-up approach, which is seen as the preferable alternative in smart city development (Mora et al., 2019a). However, this approach is normally found among those who have come further in the digitalization process. Therefore, it is likely to assume that there are both top-down and bottom-up approaches among the 58 municipalities, although many are likely to strive for a bottom-up approach.

5.2. Cross-case comparison

In this section, a cross-case comparison and analysis of the case study findings is provided. Presented in Table 3, the main findings from each case are classified and separated. Four relevant aspects are grouped and analyzed in greater detail through the following subsections: (1) the cooperation with different ecosystem actors, (2) areas where digital systems are used for operations or monitoring, (3) smart city development, open data platforms and experimental networks, and (4) different types of value to be realized.

5.2.1. Ecosystem actors

From Table 3, we see that all of the case study municipalities besides Epsilon is involved with academia, industry and other municipalities. The noticeable cooperation with academia is one of the largest differences from the most common practices discovered in the digitalization strategies analyzed in section 5.1. Delta does not currently have a formal agreement with any academic instances, but is exploring the possibilities in a pilot project together with a local university. The case studies show that the areas where academia is currently the most involved are health care, environmental services and infrastructure. Furthermore, all of the case studies claim to cooperate with industry, mostly in the form of private firms that offer technological solutions. Three municipalities expect that digitization will bring changes entailing the purchase of external services. Alpha and Epsilon, however, highlight the focus on solutions run by internal resources. However, Alpha takes an active role to facilitate the exchange of ideas and competences by hosting hackathons, ideathons and innovation labs. They are the only case municipality to involve the local industry in such a manner, and claim to have positive results.

It is found that all case studies cooperate with other municipalities. Both Alpha and Delta take part in regions with adopted, common plans for the overall digitalization of the municipalities. As previously mentioned, Epsilon represent this form of cooperative region, but the region itself also cooperates with external municipalities. Beta

	Alpha	Beta	Gamma	Delta	Epsilon
Cooperates with the following ecosystem actors:					
Industry	X	X	X	X	X
Academia	X	X	X	X*	
Other municipalities	X	X	X	X	X
International partners	X				
Areas where the municipality uses digital systems for operations and/or monitoring:**					
Health care	X	X	X	X	X
Welfare	X	X	X	X	X
Education	X	X	X*	X	
Water and draining	X	X	X	X*	
Renovation	X	X	X		
Road/street lights	X	X		X	
Parking	X	X		X	
Environmental services	X		X*		
Has programs or projects related to the following concepts:					
Smart city	X	X	X	X	
Open data	X	X	X*	X	
Data/radio networks for experimental use	X	X		X*	
Seeks to realize the following types of benefit:					
Increase process efficiency	X	X		X	X
New or improved services / business opportunities	X	X	X	X	X
Increase municipal attractiveness / better place to live	X	X	X	X	X
Cost savings	X		X	X	X
Greener environment	X		X	X	

** Exploring the idea / pilot project
** For Epsilon: Which areas are the region involved in providing common, digital solutions

Table 3: Cross-case comparison

and Gamma share ICT development strategies with other municipalities, as well as common digitalization projects. However, these cooperative agreements are not formalized with a joint strategy for the overall digitalization of the part taking municipalities. Furthermore, society in the form of residents living in the municipality is also heavily discussed. All of the case municipalities mention qualitative goals related to the quality for the inhabitants. Alpha and Gamma have projects where society gets to take an active role to facilitate innovation. Thus, society may be regarded as an important part of the ecosystem.

Norwegian municipalities and counties are independent administrative levels, and not part of the hierarchically structured state administration. The municipalities are thus responsible for carrying out good digitization and development measures in their areas of responsibility (Government, 2015). However, there are certain requirements regarding competencies and documentation which are imposed by the government. Thus, the government is considered as part of the ecosystem with digitalization of the municipalities in centre. Most of the municipalities in the case study does not argue that the demands proposed by the government pose any substantial issues or challenges. However, Epsilon raises concerns regarding small municipalities' inability to meet certain national requirements given a limited amount of financial resources.

The presence of both industry, academia, society, government and other public actors indicates that the case study municipalities utilize the quadruple or quintuple helix. Even though the involvement of academia is sparse for Delta and Epsilon, both are invested in involving society in the digitalization process which activates the fourth helix. For instance, both municipalities highlight the importance of realizing value in the form of making the municipality a better place to live for their residents. Table 3 shows that Alpha, Gamma and Delta emphasize environmental aspects in their overall digitalization strategy, utilizing the fifth helix, while Beta and Epsilon can be classified by the quadruple helix. The case study municipalities thus seem to represent ecosystems with a higher degree of cooperation, compared to the findings from the digitalization strategies. As described in section 5.1,the majority of these municipalities mainly utilized the triple helix models.

5.2.2. Areas where digital systems are used

It becomes clear that the case studies use digital systems for operations or monitoring in all of the traditional sectors such as health care, education and welfare. There are also numerous solutions related to more specific areas such as street lights, parking and environmental services, although not all of these areas are digitalized in every case study. However, several areas where analogue solutions are currently used, the municipalities have already started exploring the possibility of digitalization. Much like the findings from the digitalization strategies, it illustrates that most municipalities focus on solutions for both traditional sectors, as well as more specific challenge areas. The wide focus indicates that the case study municipalities have an integrated intervention logic, similar to the municipalities in section 5.1. Epsilon diverges from the other case studies, as we only have information on which projects the *region* have initiated, and not the total amount for each of the six municipalities within the region. Therefore, the number of areas is naturally smaller compared to the other four case studies.

5.2.3. Smart city development, open data platforms and experimental networks

Four out of five case studies have launched smart city programs with corresponding projects. Epsilon has projects with digital elements in the form of shared platforms and technologies, although not specifically calling it smart city development. Alpha and Beta are the only case studies that have their own data or radio networks for experimental or commercial use, both in the form of LoRaWAN. Meanwhile, Delta is open to investigate these opportunities in the nearest future. Furthermore, the case studies indicate that the municipalities have an understanding of issues limiting their technological advancements to be deployed.

The majority of municipalities that have a profound opinion on the usage of data are tending towards providing open data. This is a topic that is less discussed in the digitization strategies than in the case studies. Alpha, Beta and Delta are focusing on making data as accessible as possible, while maintaining privacy. The main arguments suggest that providing open data is a key driver in order to facilitate development of new services. These three municipalities can be seen to facilitate a bottom-up approach, where actors outside of the municipality are encouraged to part take in innovative measures which contribute to the overall digitalization. Gamma and Epsilon are seen to follow the more traditional top-down approach, which is often characterized by limited opportunity for residents to become engaged in the development process (Mora et al., 2019a).

5.2.4. Value

Similar to the findings from the digitalization strategies presented in section 5.1, the case study municipalities are also seeking to realize both quantitative and qualitative value. Although a mild amount of variation in the specific conceptualizations, all case studies highlight at least one of each category as a goal. Alpha, Delta and Epsilon emphasize that the desired result is not the digital solutions by themselves, but the value they will create in the form of new and improved services for the residents. These benefits are also highlighted by Beta and Gamma, where technological development is aligned with human, social, economic and environmental factors. This points towards a holistic vision, which applies to all of the case studies.

6. Discussion

The research presented in this paper aims to investigate how municipalities can realize value from digitalization through ecosystem cooperation. In this section, we consider our analysis of the empirical material from multiple digitalization strategies and five in-depth case studies. We seek to discuss our results with regards to relevant literature, and compare the findings to research from comparable Swedish municipalities. For the past year, Bjrn Laumert and Jan Markendahl from the Royal Insitute of Technology (KTH) in Stockholm have undertaken the project of *Coordinated infrastructure for smart and sustainable small cities* (SAMIR). They aim to explore needs for and limitations in small municipalities using digitalization and smart solutions for coordinated infrastructure. We have obtained up-to-date research on the cooperation within and between Swedish municipalities, and the digitalization of infrastructure in small municipalities (Claesson et al., 2019; Andersson et al., 2019). Given that 41 out of 58 municipalities represented in our researched collection of digitalization strategies are small- to medium sized, we find the comparison between our results and the Swedish study very relevant.

A key takeaway from the SAMIR study is that most problems and obstacles are not primarily technical, but stem from inadequate organization, coordination and the lack of communication between different municipal activities and administrations (Claesson et al., 2019). This is in line with our findings from the five case studies, where the main challenges were the lack of a common infrastructure, reluctance to part take in innovative, wholesome solutions, and dispersed settlement (see table A.3). Not a single case study mentioned issues where they lacked a specific technology, but instead emphasized factors such as lack of competencies or that they choose to not implement solutions without knowing the specific benefit realization compared to the cost. Our first case study, Alpha, problematize that one of their technical providers does not provide APIs that fulfill all the needs of the municipality, but wishes to sell complete solutions. This makes it difficult to buy modular solutions, and the unwillingness to cooperate seem to contribute to a lock-in effect. These findings are also in line with business development research published in 2017, where Ghanbari et al. (2017) argue that the ICT sector must be more involved in the development of services and understand how it can be profitable for other industries, in order to support the creation of IoT solutions. Thus, several factors from our findings and Swedish research indicate that the technologies are available, but cooperation and organization is not always optimal.

Our findings from the digitalization strategies have certain similarities and differences compared to the case studies composed of municipalities that are further ahead in the digitalization process. Whether this is a direct result of the maturity of the digitalization process is not possible to assert with certainty, but scholars argue that optimal approaches that utilize advantages from bottom-up and top-down perspectives develop over time as the digitalization process matures (Pflaum & Golzer, 2018). In order to bring together different actors and facilitate citizen participation in co-creation of technological advancements, measures of engagement is important (Mora et al., 2019a). Involving the residents is one of the most prominent common core strategic topic across the pool of digitalization strategies presented in Table 2. In addition to this categorization being the most heavily mentioned among the digitalization strategies, engaging the residents is also mentioned in four out of five case studies. Whether this is because the municipalities themselves have experienced positive results or trust previous research on this topic is unknown. As initially mentioned, the government has defined a long-term vision for the digitalization of the public sector, where the first priority is that users, such as citizens, public and private organizations should be in centre (Government, 2015). Meanwhile, similar wording and goals throughout the researched digitalization strategies leads us to question whether numerous municipalities are leaning towards using pre-existing, national frameworks. Further research on project plans and other initiation processes could be useful to discover whether municipalities follow up the aspects from the digitalization strategies in practice.

Swedish research shows that that diversity of different systems and system types, as well as lack of integration require both broader competence and more time to process and operate (Andersson et al., 2019). This could explain why ICT-infrastructure is the second most common development focus area among the 58 municipalities represented by the digitalization strategies. This could be an important factor in why it is necessary to see the digitalization process of municipalities in an ecosystem context. It is supported by Westerlund et al. (2014) who emphasize the holistic focus on value creation rather than individual firms delivering isolated solutions. Furthermore, lack of knowledge of both existing and future systems and IT competence prevents municipalities from acting (Andersson et al., 2019). This is also found in our case studies, where certain municipalities are looking to buy rather than develop in-house, as there are no internal programming competences. However, two of the case study municipalities highlight the focus on solutions run by internal resources, which minimizes the risk of becoming dependant on suppliers. Lastly, Swedish research shows that problems are often related to difficulties in changing working methods and activities (Andersson et al., 2019). A prominent core strategic topic among our researched digitalization strategies is leadership and competencies. This could be a factor indicating that the issue is relevant in Norway as well, as organizational development and leader training is found important in order to solve challenges.

Value is a central concept in our research question, and it shows that the goals among the common practices of the municipalities represented by the digitalization strategies does not differ far from the case study municipalities that have come further along than the average. Both qualitative and quantitative value types are heavily described, which diverges from Swedish research on the digitalization of infrastructure where the minimization of costs has a prominent focus (Claesson et al., 2019). We previously presented literature which claims that data driven enterprises are changing the traditional business models to providing services and monetizing data rather than selling traditional physical items (Pappas et al., 2018). Our case studies show that three out of five municipalities already have projects related to open data, and the fourth is planning to do so in the nearest future. The prominent focus on qualitative value in the form of service quality, user satisfaction and municipal attractivity leads us to consider the fact that the focus may have shifted from the strict fixation on monetization of products and services, to a holistic approach where qualitative goals are valued as concrete benefits to be realized. All of the case study municipalities seemed to have a holistic vision, whereas the majority of municipalities researched through the case studies were technology-led. This resonates with the literature published by McNeill (2015) and Schiavone et al. (2018) where the holistic visions can be seen as a sign of digitalization maturity.

One of the main differences between the municipalities researched through the digitalization strategies and the case studies, are that all case studies are measurably experimenting with emerging technologies. Experimental or commercial radio and data networks, sensor technology and open data are just some examples of digital solutions that are applied and tested. This type of experimentation is not only useful for the municipality itself, but is likely to influence the overall IoT ecosystem, raising awareness for the IoT in society (Aguzzi et al., 2014). Lastly, we note that the number of helices are generally higher among the case municipalities that have come further in the digitalization process, compared to the municipalities represented by the digitalization strategies. Three case studies emphasize the environmental factors, indicating the presence of a quintuple helix. According to Carayannis (2019), this will have a positive impact on society as a whole.

7. Conclusion & implications

The emergence of value networks highlights the importance of co-creating value together with involved entities in the network (Ghanbari et al., 2017). We have found that cooperation, sharing and involvement are among the most crucial strategic measures to realize value from digitalization in the researched municipalities. Municipalities rarely stand utterly alone in the digitalization process, and there are both opportunities and challenges linked to the cooperation with different actors. Similarly to findings from Swedish research, our findings suggest that few of the main issues are directly related to technological solutions, but cooperation, organization and coordination. The empirical material highlights the challenge of cooperating actors wanting to provide wholesome solutions to maintain profitability, while the municipality seek modular solutions given limited resources. Open data is also a severely discussed area, as it can be seen to facilitate growth (Mora et al., 2019a; Pflaum & Golzer, 2018). However, this includes known issues concerning security and the handling of sensitive data.

The results show many similarities between the widespread selection of municipalities, the case studies and the current situation among Swedish municipalities. The digitalization ecosystem around the municipality consists of a series of actors that are responsible to realize value from the different development focus areas. Most case study municipalities utilizes a quadruple or quintuple helix model, commonly endorsed by international leaders of the public sector (Mora et al., 2019a; Brock et al., 2018). While less digitalized municipalities often can be technology-led with top-down approaches, the majority of the further digitalized case studies tend towards holistic strategies, with a mixed approach of top-down and bottom-up approaches. The majority of municipalities in this research seem to apply integrated intervention logics.

Managers should utilize these results to make conscious decisions regarding the cooperation with other actors. As the aim for qualitative value is prominent among most municipalities, the focus can not solely revolve around the monetizing of data and services. Instead, managers need to investigate how new digital tools can be utilized to manage and operate services and infrastructures in order to create value for the residents. Although municipalities often claim to learn from other in similar situations, one of our case studies explains that many decisions are still made based on coincidences. A structured approach could be useful in order to gain beneficial synergies for multiple municipalities. Furthermore, we suggest that managers should establish a standpoint on which type of value is prioritized, as well as concrete milestones in order to be able to evaluate the performance of the implemented measures. The municipalities needs to set the long-term vision and control over the development to ensure a sustainable smart city development while developing the needed infrastructure to develop digital solutions. Digitalization thus needs to be viewed as the collection of human, social, cultural, economic and environmental factors.

As in any scientific paper, there are a few limitations. One of the case study municipalities was also represented in the pool of digitalization strategies, a decision that could have mild impact on the connection we found between the two distinct parts of our research method. One should also note that no type of bias can not be fully negligible. Further research on the topic is both useful and necessary given the emergence of new technologies combined with ecosystem thinking. Most published research concerns value realization for firms through research models, while the public sector still needs guidelines and comparable results. We suggest there should be conducted research on how the different conceptualizations of qualitative and quantitative value can be realized in practice, and what the concrete roles of the different actors could entail from a platform perspective. Also, the emergence of coopetitive relationships with non-distinct roles of competitors or cooperators could be introduced in this context to discover potential pitfalls. As suggested by Hakanen & Rajala (2018), existing research mostly focuses on the technological requirements, rather than the reason why actors should participate in collaborative value creation. This paper contributes to the theoretical knowledge base by providing a closer look at how municipalities realize value from digitalization through cooperation in their ecosystem.

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Appendix A.

Appendix A.1. Smart municipalities - Interview guide

1. Briefly about Telenor Research, the work on 5G/IoT use cases, business modes and ecosystem - how to cooperate with partners for innovation.

- FoU cooperation with KTH Stockholm

- Smart municipalities as a use case: We are interested in similarities and differences between municipalities with regards to challenges, needs and solutions

2. Regarding physical infrastructure, we wish to reach an understanding of the current situation, challenges and future plans of the municipality.

General information:
- Number of employees and organization within the municipality

A. The digitalization of infrastructure

1. In what types of municipal infrastructure and services are digital solutions utilized for operations and monitoring?

a. Construction, water, drainage, renovation, energy, road, light, transport, parking, health, education, etc

b. Does the municipality have its own data and radio networks for experimental or commercial use (eg LoRA, NB-IoT)?

2. In which types of municipal infrastructure are digital systems NOT used for operations and monitoring today?

3. Are there plans for new digital systems for municipal infrastructure and services?

B. Challenges, utility and obstacles

1. What challenges does the municipality have today, regarding different types of infrastructure and services?

2. What types of problems does the municipality think can be solved by digitalization?

3. Which obstacles does the municipality see for the implementation of digitalization?

C. City / County perspective

1. Are there any general and special challenges in this municipality regarding geography, socio-economic composition, population density, etc.?

2. How can ownership of infrastructure and management in the municipality affect the choice of ICT and IoT for the municipality's infrastructure and services?

D. Cooperation between and within municipalities

1. How does the municipality handle financing, development and operation of various infrastructures today?

a. Is there any form of coordination / cooperation with other municipalities?

b. Is there coordination / collaboration between different agencies with regard to the choice of solutions?

2. What cooperation opportunities can you see within the municipality for common ICT- and IoT strategies for different infrastructures, in order to achieve eg. critical mass and scale advantages?

3. What cooperation opportunities can you see between municipalities for a common strategy, for example when it comes to technology development, operation and organization of service offerings?

E. Digitization from a municipality/county/national perspective

1. Are there any other challenges you see within the municipality and its various business areas? (There may be other issues that can be solved with digitization that we haven't thought of)

2. Are there investigations, plans and development of infrastructure that affects the municipality, but where responsibility lies with other authorities, such as rail, highway, airport, ports?

F. Innovation and ecosystem

1. Which actors does the municipality see as relevant partners for innovation and digitalization?

2. What obstacles does the municipality see for development cooperation?

3. Do the municipality expect that digitization will bring changes such as the purchase of external services rather than solutions run by internal resources?

G. Gain Realization

1. What does the municipality see as the most important success criteria with digitalization? (rationalization, streamlining, better services, new business areas, etc)

This guide is translated from Norwegian.

Data from digitalization strategy	**Line-by-line coding**	**Conceptualization**	**Categorization**
Digitization will lead to efficient use of the municipality's resources and labor	Efficient use of resources and labor	Effective resource management	Quantitative
Standardized solutions provide fewer systems, which in turn provide less costly operations, training, and licenses	Less operational costs, less training costs, fewer licenses	Cost savings	Quantitative
Welfare technology and digital services will be used to offer quality and dignity	Service quality and dignity for users	Service quality User satisfaction	Qualitative
It is all about developing new and better services that are simple and reliable	New and better services, simple and reliable services	Service quality Innovation Usability Reliability	Qualitative
Digital tools shall contribute to higher productivity and more efficient use of resources	Higher productivity, efficient use of resources	Increase in productivity Effective resource management	Quantitative
Qualitative benefits: Better services, increased sustainability, higher user satisfaction	Better services, increased sustainability, higher user satisfaction	Service quality Sustainability User satisfaction	Qualitative

Table A.1: Open coding example (focus on perceived value)

Cluster	Categorizations	Strategies	Total codes	Conceptualizations
Actors	Academia	3	3	Universities, Technological research facilities, Innovation labs
	Government	17	29	National authorities, International jurisdiction, Guidlines and legislation
	Industry	15	22	Service providers, Partners, Suppliers, Customers
	Public actors	26	50	Municipalities, County council, State
	Society	18	34	Residents, Children, Elderly
Development focus area	Administration	9	9	Documentation, Casework, Internal management, Archiving
	Area and mobility	8	13	Planning, Construction, Geodata, Parking, Technical Services, Traffic
	Communication and information	11	12	Interaction with residents, Access to information, Social media, Mail
	Education	13	17	Digital learning tools, Pre-school technology, E-learning cloud solutions, Office 365, Digital skills
	Greener environment	4	8	Sustainability, Environmental services, Green solutions, Renewable energy
	Health care	15	19	Hospitals, Retirement facilities, Caretaking technology, Patient interaction, Patient administration systems, Home care
	House and buildings	3	5	Smart buildings, Private property, Municipal buildings
	ICT-infrastructure	16	24	Architecture, Technological infrastructure, Platforms, ICT- operations, Mobile networks, Application integrations, Standardization
	Security and privacy	17	26	Information security, Privacy, GDPR, Security threats, Sensitive data
	Welfare technology	13	24	Welfare technology, Citizen services, Life management, User centric services and products
Core strategic topic	Automated processes	20	33	Free resources, Reduce manual labor, Change employment structure, Reduce operation costs, Effectivity through standardization
	Change and innovation	5	9	Originality, Innovation culture, Pioneer, Solve societal challenges, Change management
	Cooperation, sharing and involvement	20	63	Sharing technology, Open data, Municipal cooperation, Resident involvement, Private coordination, Co-creation, Loyalty, Common solutions, KS Learning, Availability
	Evaluation and revision	9	11	Continous improvement, Project prioritization, Cost evaluation, Value measurement, Follow-up, User need assessment
	Leadership and competencies	17	25	Leader training, Specific expertise, Organizational development, Human resources, Capabilities, Leader responsibilities, Education of employees
	Self-service and usability	14	22	Self-service solutions, Proactive services, Custom language, 24-hour management, Usability, Universal design
	Wholesome solutions	3	6	Digitalization teams, Common measures, Smart city, Integration, Solid data platform, Connecting actors
Perceived value	Quantitative / financial	17	29	Increase in productivity, Effective resource management, Cost savings, Automated processes, Economic value, Efficient processing, Greater implementation capabilities, Process optimization, Greater purchasing power, Better utilization of competencies
	Qualitative / socio-economic	21	47	Service quality, Sustainability, User satisfaction, Innovation, Usability, Reliability, Democratic participation, Better work environment, Legal protection, Improved resident-municipality interactions, Privacy, Municipal attractivity

Table A.2: Clusters, categorizations and conceptualizations from NVivo coding of the digitalization strategies

	Alpha	**Beta**	**Gamma**	**Delta**	**Epsilon**
General description	Vision: to be the leading smart city in Norway with the most sensors per capita, and the most preferred city for startups, industry and academia. High population growth rate. There will be administrative changes when the municipality is part of the merging of a new region in the near future. Does not have a digitalization strategy but a smart city program and a digitalization section in the municipal plan. Strong ICT environment.	The first and current goal of Beta's digitalization process is to create an infrastructure that will serve as a basis for new ways to work. Then it will be used to develop services and applications for the residents. There is no growth in population, and the municipal operating income is currently negative. Full broadband coverage, and has LoRaWAN for experimental use.	Vision: to be the most innovative municipality in Norway. Launched a smart city program. Main goal is to facilitate innovation, development and research. Focuses digitalization towards cost reduction, provide services and improve the environment. Want to facilitate innovation and create workplaces through providing services and data to potential start-up firms.	Delta cooperates with four other regions with regards to ICT and digitalization. As a result, they have launched a common digitalization program. The goal is to improve the environment, increase inflow of citizens, facilitate academia and research, and be attractive for the industry. The smart city development is said to have a socio-economic perspective, where the success criteria are related to making the region a better place to live.	A region composed of six small municipalities, which manages the municipalities' ICT solutions and has a server park. There are five employees, who distributes applications in the region. The individual municipalities have their own hubs towards institutions and departments, but everything is linked within a common and public network. Aims to provide the residents new digital services, so called 24-hour municipalities.
Current projects	Smart water and sewage solutions Road lighting management system IoT broker system for decoding, exchange, dissemination and vizualization of data Smart city labs and ideathons Visualization of energy consumption Self-driving minibus LoRaWan Circular economy measures Smart solutions regarding health, buildings, governance, mobility and fleetmapping Open data platform	LoRaWan Parking sensors Smart street lights Smart water solutions Environment and climate data Open WiFi Digital forms Municipal chat robot Booking system for services Public information system for digitalization projects	Virtual short-term division for patients Digital communication platform Network for pumping stations Smart waste management Sensors measuring real time smart city environmental data Intune-controlled devices Smart water meters in households Electric carpark for employees Public electric bikes A "smart" gathering space	Control systems for municipal buildings Household water measurement Smart lampposts with fiber and sensors Classroom robots Health care voice and alarm functions Testing LoRaWan	Common projects within the region: Distribution of applications ICT operations Firewall and security Common projects with actors outside the region: Welfare technology platform Security alarms Regional response center

Table A.3: Findings from case studies

	Alpha	Beta	Gamma	Delta	Epsilon
Actors within the ecosystem	Alpha lists a series of stakeholders, suppliers and service providers. Different responsibilities for the digitalization process are dispersed between internal and external actors. The relationships between the actors in the ecosystem are viewed as a quadruple helix where the four cores are the public sector, industry, academia and society. A part of an international network for creating and shaping smart city data. Involvement of the public is highlighted in their strategy.	Common ICT solution with 10 other municipalities, which as operational and economical economies of scale. Has a health innovation centre with a common, regional responce center for welfare technology. Intermunicipal fire department, child care services, and educational psychology services. Several suppliers and service providers, also with regards to cloud solutions. Have guided other municipalities, and hosted an organisation for inter-governmental cooperation in the nordics. Also cooperates with research facilities such as universities and health innovation centres.	Without a big ICT-department, the operation of an own network is difficult. Thus, Gamma is looking to buy rather than develop in-house to attain competence and services. Several network providers that are in competition have done distinct parts of the fiber rollout. There is communication with other municipalities, but often without a formal structure and many decisions are based on coincidences. Gamma is a member of Smart Innovation Norway and a county-wide smart city initiative. They are also seeking to attain financial support from Innovation Norway and The Research Council of Norway.	The municipality has a ICT-department consisting of 16 employees while the cooperating region has in total of 38. Delta does not aim to host smart city technology for other municipalities, but want to cooperate with suppliers, citizens, businesses and academia. They follow a policy of only buying off-the-shelf items, but participate in innovational partnerships financed by Innovation Norway. The municipality has bought everything related to communication to external buildings and has rolled out their own fiber network. They use an external provider of technical infrastructure for communication in the health care.	Cooperates with academia, in the form of universities in the region. The region is also involved with political organizations regarding sub-elements like welfare technology. Innovation Norway is present in the current establishment phase to provide new competences. Epsilon does not cooperate directly with the private sector regarding innovation, but uses private actors as suppliers for applications and other services. Also cooperates with municipalities outside the region, where most of the ongoing projects are initated by the external municipalities.
Challenges	The municipality lacks a digitalization strategy, and is fragmented with various offices. Operational services and reporting goes at the expense of reorganization and error correction. Economic challenges are often prioritized before climate and environment, and few use public transportation. It also seems that there is a mismatch in interests between their technical infrastructure provider and the municipality. The provider does not provide APIs that fullfil all the needs, but wishes to sell complete solutions. The IT-office argues that it is difficult to buy modular solutions and the unwillingness to cooperate makes the current solution contribute to a lock-in effect. Meanwhile, they are externally challenged by the merging of counties into a new region.	Opposing forces within the municipality can be seen as a general barrier for change. Projects are mainly ran by enthusiastic initiators, but organizational impelmentation demands mobilization of the employees. Changes are done by small, incremental steps, and there is reluctance to step away from tried and trusted solutions in favor of innovative measures. Public procurement rules can make standardization problematic. Need to develop own competencies in favor of expensive colsultancy solutions. Administration and scaling of large systems with many sensors represent data issues and legal challenges.	A principal challenge for Gamma is the dispersed settlement, leading to poor fiber coverage and quality. Private network providers will not improve todays standard because it is not profitable. Meanwhile, Gamma is seen as a low income municipality with low tax income. Most people commute to larger municipalities. There are challenges related to data formats not being standardized, and that they have no programming competences. Gamma may be merged with other municipalities in the nearest future. Although learning from other municipalities, there is no common structure or procedures regarding cooperating on digitalization.	Delta is experiencing challenges related to singular systems or industry solutions not being able to communicate with each other. The dataset is not coordinated, some are hard to interpret, and has different definitions and terminology. The region also struggles with network coverage. Another challenge is the storing of data as the data is deleted after 30 days. The data is also difficult and slow to access as the portals are slow to open. Delta is not on the ROBEK list, but are struggling with infrastructure and transportation. There are issues regarding utilizing large amouts of data in which parts contain sensitive information.	Epsilon sees digitalization as 80% organizational development, meaning that a key task is to manage human resources. None of the municipalities have redundant administrative resources, and the financial resources are generally limited. There is a decline in the population, and disperse settlement. Need to free up capacity, and streamline work processes. There are issues related to establishing high-speed broad band, as well as challenges in developing the municipality's digital processes within fields such as welfare technology. All municipalities taking part in the collaboration needs to be invested.

Table A.3: Findings from case studies

6 Conclusion

Through this thesis, we have presented theory related to the digitalization of municipalities. The theoretical basis presents several digitalization strategies and cases to identify similarities. As Westerlund et al. (2014) argues, business model theory are moving towards the business ecosystem theory where collaboration has gotten a higher importance. The findings in our article supports the theory as cooperation, sharing and involvement were identified as important measures. The empirical and statistical data on digitalization in Norwegian municipalities also indicate the need for collaboration.

However, some topics within the literature base presented in section 3 were not included in the article. For instance, the business model derived by Schiavone et al. (2018) is quite complex. Although it has the added benefit of representing a smart city in a very detailed manner, as mentioned in subsection 3.1.1, it is too detailed to explain the more abstract aspects of the business models and the relationships between the components. Even though the concepts are informative, it is not commonly seen as an optimal framework for analyzing the digitalization of firms. This might be given the increased focus on collaboration, as the business model tends towards being more neutral, and prioritize all aspects.

This moved us onto the business ecosystem theory that focuses more on relationships by taking the ecosystem-perspective. Leminen et al. (2018) present four types of business models. In the context of digitalization in Norway, the Collaborative Commons seems the type that fits our findings. The findings suggest a focus on collaboration and working towards a sharing culture, but at the same time, the solutions are often quite specifically developed for single purposes. An example would be Bossnett from Bergen which has the single purpose of collecting garbage. The Norwegian IoT ecosystem has not yet moved towards the platform business model which Leminen et al. (2018) argues Collaborative commons will eventually transform to. The IoT-ecosystem is still in its early years, and there has not emerged a dominant actor in the ecosystem yet. However, empirical evidence suggest that the Norwegian IoT ecosystem is moving towards the type, considering the focus on providing open data through platforms.

The municipalities have shown the will to create the ecosystems necessary for digital and IoT development. Certain case study municipalities are following the steps recommended by Papert and Pflaum (2017). Development focuses and smart city programs are initiating a number of projects, aiming towards smarter municipalities. Events and workshops held by some municipalities facilitate the idea-creation process, and thus the definition of IoT services that should be realized. At the same time, others are specifically looking at how they can contribute to the ecosystem. From the findings in the article many of the municipalities that are further along in the digitalization process tend to experiment and initiate numerous innovation related projects. Similarly to findings from Swedish research, our findings suggest that few of the main issues are directly related to technological solutions. Instead, empirical evidence suggest that there are certain organizational challenges that needs to be solved in order for value to be realized and the ecosystem to thrive.

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