Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology Management

Knut Andreas Vågen

Internet of Things - Public-Private Partnerships for Innovation and Digitalization in Smart Municipalities

Master's thesis in Industriell Økonomi og Teknologiledelse
Supervisor: Per Jonny Nesse
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Abstract

The Internet of Things constitutes a fourth industrial revolution affecting most areas of society. Through IoT and other digital solutions Norwegian municipalities are expected to save 100 billion NOK in the next 10 years (Mellbye & Gierløff, 2018). To realize these savings the private sector is expected to play a significant role. This review seeks to uncover the characteristics of public-private partnerships working on Internet of Things projects in Norwegian municipalities. Through applying relevant theory and interviewing relevant parties I have sought to answer two research questions. The first research questions is "how does digitalization and innovation happen in Public-Private Partnerships?" In addition to uncovering the characteristics of these partnerships the second research question is "What are the barriers for innovation and digitalization that is encountered in these partnerships and how can they be mitigated?"

To answer the research questions a small literature review has been conducted to find the most recent research on smart cities, digitalization and innovative partnerships and networks in these fields. Through the review it has been found that innovative smart city projects are often classified in either an explorative or exploitative category (Ferraris, Santoro, & Papa, 2018; Nielsen, Baer, & Lindkvist, 2019). It has also become apparent that an Open innovation framework is often applied because of the collaborative aspects of smart cities and other public IoT projects (Hosseini, Frank, Fridgen, & Heger, 2018; Schaffers et al., 2011). Other fields of research such as business ecosystems and the triple helix model of innovation has also been included.

In addition to the literature review, a total of 9 interviews has been done with people representing private, municipal and academic institutions in different IoT and smart city projects. Several of these informants are taking part in Public-Private Partnerships where a municipality is either implementing IoT solutions or aiding a private party in developing new and innovative IoT solution that is intended to aid smart municipalities in realizing significant benefits later. Through a thorough coding process of all the interviews I have made several interesting findings, including a typology of four types of innovative Public-Private Partnerships in Norwegian municipalities

The typology consists of four types of partnerships that is grouped along two dimensions where one is an explorative-exploitative dimension and the other is whether it is the municipal or private party that is managing the IoT project. It was found that the clearest benefits for the municipality was in the exploitative projects. Also, if the municipality managed the project, there was significantly more competence building in the municipality compared to when it was managed by the private party.

In addition to the typology, a set of barriers has been found related to three different categories. The first is collaborative barriers that is to a large degree related to public procurement rules and slow municipal processes which seems to be a barrier of innovation. Other barriers relate to the organisation such as risk-aversity, disincentives and most importantly a lack of competence. Regarding the lack of competence, universities and academic institutions could play a role in increasing the competence level in municipalities. Lastly, contextual barriers relate partially to costs, but more importantly, numerous proprietary solutions in the IoT ecosystem creates issues for municipalities which ends up having numerous IoT solutions without the ability to work together.

Sammendrag

Fremtredenen av tingenes internett (IoT) blir ofte kalt den fjerde industrielle revolusjonen og påvirker de fleste områdene av samfunnet. Gjennom IoT og andre digitale løsninger er norske kommuner forventet å spare 100 milliarder korner over de neste 10 årene (Mellbye & Gierløff, 2018). For å oppnå disse innsparingene så er privat sektor forventet å spille en viktig rolle. Denne forskningen har som mål å avdekke karakteristikker ved offentlig-private partnerskap som jobber med IoT i norske kommuner. Som utgangspunkt stilles det to forskningsspørsmål. Det første spør «hvordan skjer digitalisering og innovasjon i norske kommuner gjennom offentlig-private partnerskap?» I tillegg til dette, stilles er det andre forskningsspørsmålet «hva er barrierene for innovasjon og digitalisering man møter på i disse partnerskapene og hvordan kan de bli dempet?»

For å svare på disse forskningsspørsmålene så har en liten litteraturgjennomgang blitt gjort for å finne den nyeste forskningen relatert til forskningsspørsmålene. Gjennomgangen har vist at innovative smart city prosjekt ofte blir klassifisert som «utforskende» eller «utnyttende» (Ferraris et al., 2018; Nielsen et al., 2019). Videre har det også vist seg at rammeverk relatert til åpen innovasjon ofte blir benyttet på grunn av samarbeidsaspektet med disse prosjektene (Hosseini et al., 2018; Schaffers et al., 2011). Annen teori relatert til business økosystem og triple helix modellen for innovasjon er også inkludert i gjennomgangen.

I tillegg til litteraturgjennomgangen har 9 intervju blitt gjort med aktører fra privat næringsliv, kommuner og akademiske institusjoner som jobber med IoT og smart kommuner. Mange av disse intervjuobjektene jobber med offentlig-private partnerskap hvor en kommune enten implementerer en IoT løsning eller bistår en privat aktør i å utvikle nye IoT løsninger som kan gi kommunen innsparinger på sikt. Gjennom en grundig kodeprosess av alle intervjuene har en rekke interessante funn blitt gjort, blant annet en typologi med 4 typer offentlig-private partnerskap i norske kommuner.

Typologien består av fire typer partnerskap som er gruppert langs to dimensjoner hvor den ene er langs en utforskende-utnyttende dimensjon og den andre er relatert til om det er kommunen eller den private parten som har styringen i prosjektet. Det viser seg at nytten for kommunen var tydeligst i de utnyttende prosjektene. Videre viser det seg at i de tilfellene der kommunen har styringen i prosjektet oppnår de betydelig mer kompetansebygging enn når den private parten har styringen.

I tillegg til typologien er en rekke barrierer for innovasjon og digitalisering funnet fordelt på tre hovedkategorier. Den første er relatert til samarbeid og består i stor grad av offentlige anskaffelsesprosesser og trege kommunale prosesser. Andre barrierer er knyttet til den kommunale organisasjonen som risiko-aversjon, dis-insentiv og mangel på kompetanse. Angående mangel på kompetanse så kan universitet og akademiske institusjoner spille en viktig rolle i å heve kompetansenivået til norske kommuner. Til sist er det de kontekstuelle barrierene som relaterer til høye kostnader samt problem relatert til det større økosystemet som for mange proprietære løsninger og mangel på felles standarder.

Preface

This master thesis is the final delivery of the Master of Science program in Strategy and International Business Development which is a part of Indsutrial Economics and Technology management at the Norwegian University of Science and Technology (NTNU).

I would like to express my gratitude to Per Jonny Nesse for great guidance and insight throughout the work on this thesis.

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Abbreviatons

4G/5G	4th and 5th generation connectivity technology for mobile networks
4P	Public-Private-People partnerships
AI	Artificial Intelligence
DESI	The Digital Economy and Society Index by the EU commission
ICT	Information and communications technology
IoT	Internet of Things
LTE-M	"Long Term Evolution for Machines" is a mobile network connectivity technology for the Internet of Things
LORAWAN	**Lo**ng **Ra**nge Wireless Area Network is a proprietary connectivity technology for the Internet of Things
MNO	Mobile Network Operator
NB-IoT	Narrowband-IoT is a mobile network connectivity technology for the Internet of Things
PPP	Public-private Partnerships

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1 Introduction

For decades the internet has been a mean for people to connect to each other, however in recent years this has started to change. The emergence of the Internet of Things has made the internet a place where predominantly things can communicate, rather than people. Through increasingly cheaper devices with sensors and batteries and the means of new and better connectivity technology the Internet of Things is booming with 14 billion devices connected in 2019 (Gartner, 2018). With an exponential increase in connected devices, it is becoming increasingly clear why the emergence of the Internet of Things is being called the fourth industrial revolution (Lasi, Kemper, Feld, & Hoffmann, 2014). Many industries are being transformed, including the public sector, which leads to new strategic considerations being made (Porter & Heppelmann, 2014).

Collaborative efforts are central to IoT development because of the many technical components needed for an IoT system to work. A central theme in such collaboration is Open innovation, a term first coined in 2003 (Chesbrough, 2003). The idea of relying on knowledge sources outside of the firm to innovate has been getting increasing attention in the years since the term was introduced and the benefits of partaking in such collaborations has been extensively researched (West & Bogers, 2017). While Open Innovation research is abundant, very little focused has been given to Open Innovation activities in public organisations. It is only in recent years that Open Innovation models for public organisations has been suggested, and since then it has been given limited attention (West & Bogers, 2017). Thus, research on the topic is still in it's infancy (Ferraris, Santoro, & Pellicelli, 2020).

Digitalization and IoT has an enormous potential in Norwegian municipalities with cost savings expected to be 100 billion NOK the next ten years (Mellbye & Gierløff, 2018). To realize this potential municipalities must collaborate with other municipalities, private actors and academia (Chang, Mikalsen, Nesse, & Erdal, 2020). By using Mellbye & Gierløff's (2018) division of the municipality operational areas in three, the areas with the most potential for digitalization becomes apparent. Health services is one area where the use of welfare technology, which often consists of IoT technology, is expected to provide significant benefits through allowing elders to live longer at home (Østbye, 2020). Other areas related to municipal administration, property management and citizen services such as smart water grids are areas where the use of IoT can lead to increased sustainability (Farmanbar, Parham, Arild, & Rong, 2019).

To realize these benefits the municipality is dependent on private parties to innovate and implement these digital solutions. Such reliance on private parties can happen through reliance on a larger ecosystem (Chang et al., 2020), as well as Public-Private partnerships (PPPs) (The Economist, 2016). In this review the main focus will be public-private partnerships, however, considerations will be made in respect to the larger ecosystem. To digitalize and create new solution, it is essential for municipalities or government to include private parties with the right expertise to develop these things, although, it must happen in collaboration with the municipality (Cheong, Choi, & Lee, 2015; The Economist, 2016). Therefore, applying an Open innovation framework to analyse innovative partnerships is arguably very suitable.

Applying an open innovation framework towards municipalities is often done in Smart city projects where IoT often plays an important role (Hosseini et al., 2018; Schaffers et al., 2011). Ferraris, Santoro, & Papa (2018) research on the phenomenon sees two distinct types of innovative partnerships that makes up these collaborations, which are explorative and exploitative partnerships.

The purpose of this review is to further examine the relationships between municipalities and private actors in the field of IoT. Theory on innovation and ecosystems will be used as a lens to understand the mechanisms in these relationships and how they contribute to innovation and digitalization as well as potential barriers occurring in these relationships. In an international context Norway is doing quite well on digitalization, thus, researching these themes in a Norwegian context may benefit other less developed countries at a later time as they come further in the digital transformation. Furthermore, in a Norwegian context these themes are not widely research and therefore it is suited to make valuable contribution to research. As a basis for this review two research questions are chosen, the first of which is as follows:

RQ1: How does digitalization and innovation happen in Public-Private Partnerships?

With a core focus on IoT projects and municipal-private partnerships the activities in these partnerships are discovered as well as the benefits and motivations for the parties involved. One important distinguishing feature of this study compared to Ferraris18 is that it takes on the perspective of private as well as the municipal parties in addition to other stakeholders. Having both an inside and outside perspective on municipal innovation is essential to understand how innovation and digitalization is happening as well as what the long-term benefits could be.

Digitalization does not come without issues. It requires significant organisational change for it to provide the expected benefits (Skjelvan, 2015). In addition to this, barriers to adoption of smart water grids range from cost, security, issues with adoption and lack of technological capabilities and governance in public actors (Cheong et al., 2015). Other areas of the municipality experience similar issues, especially related to technological capabilities (Holthe, Lund, & Landmark, 2017). Many of these issues often materialize in the public-private partnerships because of different organisational cultures and structure. Exploring these barriers as well as ways to overcome the barriers is therefore highly relevant for digitalization and innovative efforts in municipalities. Therefor the second research question is:

RQ2: What are the barriers for innovation and digitalization that is encountered in these partnerships and how can they be mitigated?

2 Litterature

2.1 Business Ecosystems

The term business ecosystem stems from Moore's (1993) article *A new ecology of competition* where he argues that thinking in terms of industries and networks should be a thing of the past. Rather, one should regard a firm's surroundings as an ecosystem to fully understand the underlying mechanisms that drive change. Initially an ecosystem consists of many unstructured elements and actors, but as time goes on a structure emerges where usually one or two actors has the position as leaders. In the early stages of an ecosystem's formation, positioning a firm to take on a leadership position or at least a profitable one is essential. This can be done through choosing the right partners, the right value proposition and making sure that one has some type of capability or resource that will stay valuable for a long time.

In the later stages of an ecosystem, assuring that the ecosystem has an ability to expand quickly to meet market demand is essential (Moore, 1993). Furthermore, holding on to a leadership position and motivating all parts of the ecosystem to innovate quickly becomes the key strategic concerns. The latter is especially important, since when having an ecosystem view, the competition between different firms is secondary to the competition between different ecosystems. With that in mind, it becomes essential to assure that all of the ecosystem is doing its part and innovating as well as staying motivated to remain in the ecosystem.

This notion is supported by Iansiti & Levien (2004). With a focus on the ecosystem leader, which they label the keystone actor, they argue that the leader must look beyond their own firm in the ecosystem. Through the strategic choices being made, a firm must assure that the entirety of the ecosystem is healthy and making a profit. Disregarding this may lead to less innovativeness among actors with little to earn or actors disappearing from ecosystems, either through choosing to leave or buckling under.

Many ecosystems are centred around a platform where the platform owner usually is the keystone actor in the ecosystem (Gawer & Cusumano, 2014). This role is especially because of the value the platform is given through network effects. Theory on platform ecosystems is a wider field of research also including digital platforms (Helfat & Raubitschek, 2018). The mechanisms related to these are similar to other industry platforms.

Overall, the key takeaway from ecosystem theory is that industry boundaries are disappearing and that when considering the environment, a firm operates in far more actors should be taken into consideration.

2.2 Innovation

Ensuring continuous innovation both in early and late stages of an ecosystem is essential. Without such innovations, an ecosystem will see death as new technology and other ecosystems emerge to out-compete them (Moore, 1993). The theory on innovation will be addressed through two lines of research. First, theory related to explorative and exploitative innovation will be addressed, before the field of Open innovation will be looked at a bit more in-depth than the former.

2.2.1 Exploration, exploitation and the ambidextrous organisation

Classifying innovations as either explorative or exploitative has been done by many, including March (1991). In short, exploitative innovations build on a firms existing competence, business areas and technology while its counterpart, explorative innovation explores completely new business areas and activities. For a firm, explorative innovations often lead to new business models or a completely new market for the firm. March's (1991) research shows that there is a tension between exploitation and exploration activities in a firm where one activity is performed at the expense of the other. Strategies of solving this tension is well known in organisational theory. Raisch & Birkinshaw (2008) discuss the ambidextrous organisation which can both exploit existing ideas while also exploring new ideas, without these activities happening at the expense of the other. The strategies chosen to make an organisation ambidextrous is among others to move the explorative innovation activities into their own business units so that they can remain as independent from the core activities and maybe more conservative, risk-adverse culture of the main organisation.

2.2.2 Open Innovation

Collaborating on innovations is not new, however, it took until 2003 for a new research paradigm and label to such collaborations to emerge. Chesbrough (2003) argues that we have been moving into a new paradigm where firms are increasingly depending on sources of innovation outside of their own firm. Furthermore, a firm's own innovations that doesn't fit their own core activities may be shared with the public or selected partners so that the ideas can live on in another market. How the latter effect can benefit the firm is not immediately intuitive, however, benefits from sharing may show itself in both expected and unexpected ways down the line.

Chesbrough (2003) mainly discuss what is labelled as inside-out innovation and outside-in innovation, depending on whether the ideas flow from inside the firm to the outside. Gassmann & Enkel (2007) expands on this and introduces a third archetype of open innovation. The coupled innovation process is a combination of the two former types where two or more firms co-operate on developing a new technology or business model. Interestingly enough, this type of model have also been used between universities and private actors implying that the field is relevant beyond the private sector (Gassmann & Enkel, 2007).

Open innovation may also be linked to strategy and how a firm could be of benefit to an ecosystem as well as benefit from an ecosystem (H. W. Chesbrough & Appleyard, 2007). This aspect however, often relates the most to large MNCs or platform providers. However, open innovation activities is also highly relevant for smaller enterprises as well H. Chesbrough (2010). Their small size enables them to go after smaller niche markets and provides flexibility to pursue the most promising routes. The benefit of spreading risk and tapping into large pools of resources outside the firm is also an important benefit.

Open innovation research has mainly been focused on collaborations between different firms and not between public organisations and private firms (West & Bogers, 2017). However, the business models underlying Open Innovation theory has been shown to be relevant for not-for-profit public organisations as well (Chesbrough and Bogers (2014) as cited in West & Bogers, 2017). This indicates that public organisations can and should take advantage of the benefits of open innovation, and so should the private firms working towards the public sector.

2.2.3 Triple Helix model of Innovation and expanded helixes

As stated, universities are sometimes involved in different Open innovation projects (Gassmann & Enkel, 2007). The university taking on such a role in the private and public sector is described through the Triple Helix model of innovation. The triple helix model of innovation is used to describe how government, industry and academia together drive innovation and economic growth and was first proposed by Etzkowitz & Leydesdorff (2000). According to them, industry-government-academia relations has been present for a long time, however the way it is organised is starting to change with the three actors being closer knit together so that close collaboration arenas may emerge. Such collaboration arenas can be everything from laboratories, academic research groups, university spin-off firms as well as other initiatives.

Traditionally the roles of the different actors have been well-defined(Etzkowitz & Leydesdorff, 2000). The government is responsible for the laws, funding for the universities and that the environment in which the private actors operate in is facilitated to allow for economic growth. The university has traditionally been a teaching institution but is increasingly seeing its role becoming more research focused and even doing more direct contributions to industry. Lastly, the industry is where much of the production is happening and it is much the same, even though it surely notices the effect of the university being more involved and willing to contribute. All over, the emergence of triple helix model of innovation sees the roles of the three actors changing as well as the relationships between them.

Since the introduction of the triple helix model of innovation, expanded frameworks has emerged. By including society, or citizens, as a fourth actor in the triple helix model, you attain what is called the quadruple helix. This can be further expanded by including the environment in the model which along with society makes up the quintuple helix model (Carayannis, Grigoroudis, Campbell, Meissner, & Stamati, 2018). In addition to this, another expanded Helix is proposed by Reve (2017). This model suggests including entrepreneurs and investors in the triple helix model to make up an expanded helix model. The two approaches to expanding the triple helix model is quite different, however, what they do have in common is that they argue that there are more sources of innovation that one must be aware of beyond the university, state and industry.

2.3 IoT, Digitalization and Smart Cities

2.3.1 IoT and Digitalization

For many decades there has been a trend of increased use of computers, the internet, and more recently smart phones (Skjelvan, 2015). This trend impacts many organizations in that things that were previously done manually and on paper is now done online and on centralized servers. The term that is most often used for this is digitalization. Central to digitalization processes is replacing paper with digital solutions as well as automating manual tasks. This kind of trend leads to significant organisational changes and therefore the theme of digitalization is just as much about the technology as the organisational change that comes with it (Skjelvan, 2015). Such organisational change may be difficult, but it does give significant benefits. Through the use of technology and organisational change, digitalization is a key enabler for economic growth and improved public services (Rybalka, Røgeberg, & Dyngen, 2019).

A subset of digitalization is the emergence of the Internet of Things, often shortened to IoT. In short, the Internet of Things represents the change from the internet being about connecting people to be about connecting "things". These things are defined by Porter & Heppelmann (2014) to consist of three elements.

- Physical component: e.g. a car, coffee machine, smart watch
- Smart component: Typically, a sensor and a microprocessor
- Connectivity: the ability to connect to the internet in one way or another, usually through some wireless connectivity solution

Porter & Heppelmann (2014) argues that the emergence of such components will have significant effect on strategy and the way organisations work. This is made even more clear when the sheer size of the Internet of things is considered. Gartner (2018) claims that in 2019 14.2 billion things were connected to the internet with an expectation for it to grow to 25 billion by 2021. With such a dramatic increase in connected devices it is clear that it will have a profound effect on the world. In fact, many scholars and managers refer to this trend as the fourth industrial revolution, or Industry 4.0, signifying that the Internet of Things is affecting society to a similar extent as the previous industrial revolutions (Bullinger, Neuhüttler, Nägele, & Woyke, 2017; Woodhead, Stephenson, & Morrey, 2018)

2.3.2 Connectivity technology for the Internet of Things

An important enabler of IoT technology is the different connectivity technology that is available. The multitude of different technologies is different in terms of range, proprietary vs. non-proprietary, data usage and several other characteristics which determine appropriate use areas. In Figure 2.1, taken from Li, Xu, & Zhao (2018) the main connectivity technologies is presented based on a certain technology's range and different characteristics. Bluetooth is a typical low range connectivity type used when objects are quite close. Technologies more suitable for local networking, such as within one's home, is Wi-Fi and the less known Zigbee which is made especially for IoT applications. Technologies allowing long rages, such as cities, is often mobile networks offered by a Mobile Network operator. However, the normal protocols one use with phones are often not suitable for IoT applications because of high energy use. Therefore, MNOs all over the world are offering Narrowband-IoT(NB-IOT) and LTE-M which is similar to 4G, but with much smaller data packets, it is easier on the power consumption. The technology is available through 4G networks and will also be available through 5G as it is gradually introduced today. Considering the Norwegian context, both LTE-M and NB-IoT are rolled out nationally which puts it in the more developed countries, also in a western context, in terms of connectivity (GSMA, n.d.). Having access to these connectivity technologies makes Norway suitable for IoT development and implementation. Lastly, LORA networks is a proprietary solution that is not managed by a central actor such as an MNO, but rather the ones who intend to use it, such as a municipality or private firm.

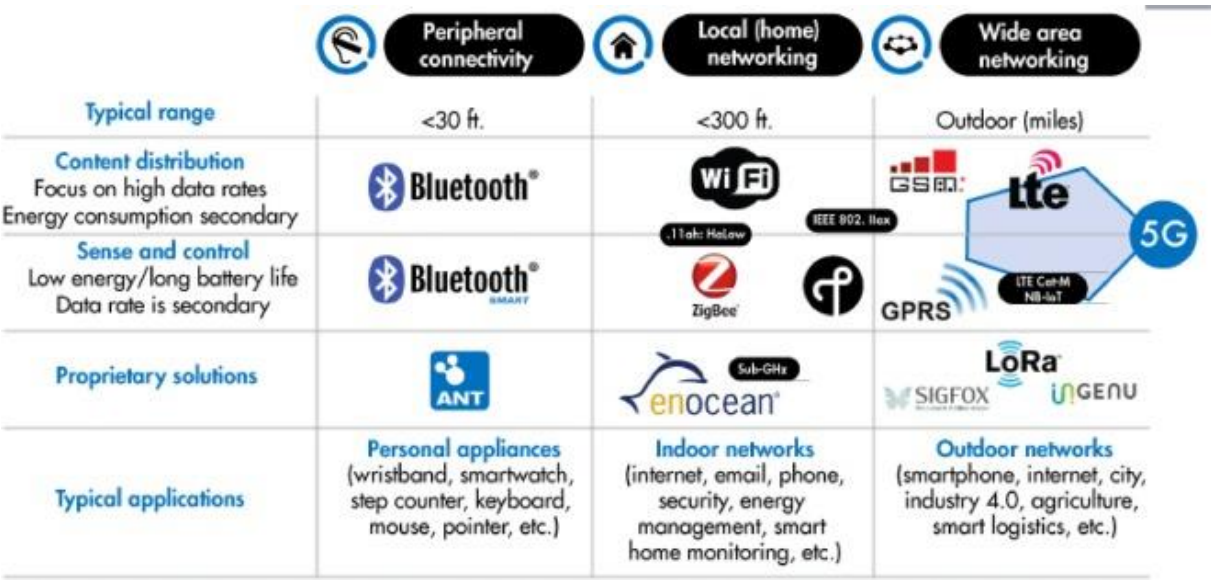


Figure 2.1 Connectivity technology for the IoT (Li et al., 2018)

Which technology to choose depends a lot on the use area of the technology, however, one of the most important aspects is the power consumption of a protocol. 60% of applications require low power consumption, long battery life and wide coverage (Li et al., 2018). This is the background for the emergence of LORA, LTE-M and NB-IoT technology alongside increasingly better battery technology. All over, the new connectivity standards alongside better technology related to the sensors such as battery and power consumption plays an important role in enabling the IoT to grow significantly in years to come.

2.3.3 Smart cities and smart municipalities

A recurring theme in the field of IoT and an important use area for the technology is the smart city. Smart city research is becoming increasingly abundant, however, a clear definition of what a smart city is has not been agreed on by researchers and managers. (Albino, Berardi, & Dangelico, 2015). The Smart City concept is partly used on technological aspects, which often includes Internet of Things, however, other dimensions that may be considered central to a smart city is citizen involvement and focusing on education and human capital. According to Albino et al. (2015) a reason for the diverging definitions of the Smart City may be because it is often applied to different domains. The "hard" domains such as buildings, energy grids, water management, logistics etc. often has ICT, and in extension IoT, playing an important role, while in other "soft" domains such as education, culture, social inclusion etc. ICT does not necessarily play a decisive role. As IoT is the central theme of this paper, more focus will be applied to the "hard" domains rather than the soft.

A useful distinction to separate the different application areas for the smart cities is presented by Schaffers et al. (2011) who identify three main application areas. First of all it is the smart economy which seeks to aid businesses and thus grow the economy. Second is the city infrastructure and utilities which is related to transport, smart grids and environment monitoring. This is an area where IoT plays the largest role, such as the monitoring of water grids which holds potential for significant energy and water savings (Farmanbar et al., 2019). Lastly, the area of governance which focuses on government services, democracy and open data. All in all, the concept of the smart city is quite diverse and contains many different application areas.

Smart municipality is a term that is in many ways synonymous to smart cities, however, it has a much wider definition since it references elements beyond the city itself. Smart grids as suggested by Farmanbar et al. (2019) is one such application that is highly relevant outside of the city. Furthermore, Mellbye & Gierløff (2018) includes areas such as healthcare in the analysis of smart municipalities, which is not part of the city itself. All over, smart municipalities reference the entirety of a municipality and the ways in which digitalization impacts it. Thus, a smart municipality has many common denominators to the smart city,but differs in that the smart municipality references the entirety of a municipality and that the smart city is often focused on the "soft" domains such as education, culture and social inclusion. Still, the overlap and similarities between smart municipalities and smart cities is significant and therefore theory and statistics on each of them is likely relevant to the other.

2.3.4 Welfare technology

One of the largest domains where IoT is used in the public sector is in relation to welfare technology. In short, it is a collective term used for different ICT technology used in the health sector where the goal is either better care or allowing elders to live longer at home (Østbye, 2020). Lo, Waldahl, & Antonsen (2019) attempts to define the key characteristics of welfare technology to further understand what the ambiguous term actually entails. The three main characteristics is that welfare technology is that it's inter-disciplinary, connected and ubiquitous. What is meant by inter-disciplinary is intuitively understood, however, the connected term here refers to the multitude of welfare technology being connected to each other. Furthermore, the ubiquitous term refers to welfare technology having a significant effect on the organisation as well as the work processes of the individuals within it. All over, the welfare technology term is not well-defined but has some common important characteristics that is worth keeping in mind.

Use of welfare technology is expected to increase drastically in the coming years with the population becoming increasingly older (Holthe et al., 2017). A key goal of using welfare technology is to allow older people to live longer at home and thus saving municipalities and the public health sector for the large costs of elderly care homes. However, similarly to all digitalization processes, implementing and using welfare technology does not come without challenges (Holthe et al., 2017). However, again, this is an area where the benefits of cost savings combined with other benefits far outweigh the cost and other drawbacks.

2.4 Public-Private partnerships

Governments and municipalities often rely on private firms as suppliers of services. Many of the relationships governmental institutions has to private parties falls under the term "public-private partnerships", PPP for short. There is no common definition of the term and they do vary in scope. One way to define a PPP is as a "co-operation of some sort of durability between public and private actors in which they jointly develop products and services and share risks, costs and resources which are connected with these products(van Ham and Koppenjan (2001:598) as cited by Hodge & Greve, 2007). Other narrower definitions exist, and it has also been used as an interchangeable term to "privatization" or "contracting" (Hodge & Greve, 2007). For the sake of this research, a wider definition will be used to include innovative and experimental projects that otherwise would be excluded in the original definition.

A 2016 study by The Economist Intelligence Unit on smart cities argues for the increased use of such partnerships to drive the development of smart cities. Here PPPs are defined as a deeper type of collaboration between public and private organisations, contrary to supplier and customer relationships that cities often structure relationships with private parties as (The Economist, 2016). The Economist study emphasizes the private sectors desire for increased involvement in smart city projects and suggests that open innovation strategies may be fruitful for the city. Scuotto, Ferraris, & Bresciani's (2016) smart city research delves into several IBM smart city projects with a main focus on IoT and Open innovation. A central topic of the article was the relationship between IBM and the public counterpart where both characteristics and barriers were identified. A key objective for IBM was to use the cities as a testbed where they could test their technology and increase their knowledge flows. Other objectives of the smart city projects that the city benefitted from as well was increased value for the citizens and an increased sustainable economic growth. The barriers in the project was partly related to IP rights, where IBM was wary of sharing knowledge related to their core competence. Other barriers were related to scarce managerial competence and technical knowledge as well as a passive role of city representatives.

Scuotto et al. (2016) argue that these barriers could be mitigated by including academia and consulting firms as intermediaries. Furthermore, IBM informants claim that IBM is more likely to work with cities that are closely embedded with other innovative cities, in part because this accelerates the city’s learning which may mitigate the barrier that is the lack of knowledge. All in all, this speaks for an ecosystemic perspective on Smart City projects, arguing that it is important to have more than just the private-public partnerships, but also other actors that can aid with knowledge inflows and an intermediating role.

Ferraris, Santoro, & Papa (2018) has looked more closely at private-public partnerships and how private firms manages open innovation with public partners in smart city projects. They made observations through theory and empirical material that public organisations are very different from private firms in several areas. First, public organisations have no competitors and usually have long decision-making processes. There is also a very weak absorptive capacity, meaning that organisational learning is likely to be quite slow in public organisation. Furthermore, public organisations are often risk averse compared to their private counterparts. Lastly, trust issues may arise between private and public organisations, which calls for active trust building in initial phases. The authors of the study proposed a framework for understanding the innovation process in public-private partnerships which will be addressed in section 2.6.

2.5 Internet of Things Ecosystems

There is a general consensus in IoT research that one should choose an open ecosystem strategy (Porter & Heppelmann, 2014; Westerlund, Leminen, & Rajahonka, 2014). The advantages of a closed approach is evident, however, closed ecosystems will struggle to compete with open ecosystem because of faster development and customers resistance to limiting of their options (Porter & Heppelmann, 2014). In the selected theory three general dimensions were found that addresses the ecosystemic view of IoT towards the public sector; the technological dimension, the business model dimension and a more general collaborative dimension.

2.5.1 Techonological dimension

The choices of a firm to have an open or closed ecosystem usually manifests itself in the technology. Hosseini, Frank, Fridgen, & Heger's (2018) research on smart towns strongly discouraged "silo-thinking" where different services and systems is closed and unable to communicate and work together. This sentiment is also supported by Ahlers, Wienhofen, Petersen, & Anvaari (2019) which argue for keeping everything as open as possible when designing smart city ecosystems. Openness when it comes to Open APIs, documentation, loose coupling between different functions and open data are some of the principles proposed that allow ICT infrastructure to be effective and replicable in the Smart city domain (Ahlers et al., 2019).

While the construction industry is in many ways peripheral to smart cities and municipal digitalization, Woodhead, Stephenson, & Morrey's (2018) study on digital solutions in the construction industry presents learnings applicable far beyond the construction industry itself. The general argument of their article is that to achieve the full potential of IoT and digitalization in general, one must move away from point solutions to an IoT ecosystem. Point solutions are solutions made for one use case in one business area that doesn't work with other digital solutions. This acts as an inhibitor of innovation and thus, a different strategy should be applied. The authors argues for creating a digital layer where different systems can communicate and where data generated is openly available. In other words, one should move away from "silo-thinking" to thinking in terms of an IoT ecosystem.

The issue of vertical silos is also addressed by Robert et al. (2017) in their study of an open IoT Ecosystem in Lyon. Having vertical silos is slowing down development in the IoT area and is a key reason that IoT is yet to deliver on its grand promises. Solving the issue of vertical silos is best done through using open standards in all IoT applications so that they are interoperable. Such open standards is synonymous to Woodhead et al.'s (2018) "digital layer" which allows all systems and applications to talk together and provide additional value. Still, while it is increasingly clear that open ecosystems is the way to go, work still lays ahead on agreeing on exactly which standards should be chosen as the lingua franca of the Internet of Things (Robert et al., 2017).

2.5.2 Open data

Open data is an important principle to drive innovation in a city. Ahlers et al. (2019) emphasizes this and finds that this is an important strategy in Trondheim which aims to open up as much data as possible within legal boundaries. Allowing third parties to use data the city is collecting through IoT and other means, can drive business growth and innovation in the private sector in a city. This goal is often so important for smart cities that it is included in many smarty city definitions (Albino et al., 2015).

There is a clear benefit to opening up data sources, however, according to Abella, Ortiz-de-Urbina-Criado, & De-Pablos-Heredero (2017) the process in which data is reused is not well defined. They propose a three-step model to analyse this process, starting with considering the quality of the data along six dimensions. The following steps is related to the value the data ultimately creates. First, is the reuse value is considered based on direct feedback and the degree it is used. Lastly, the economic and social value for the ecosystem is considered. This type of frameworks may allow cities to better measure the impact of different smart initiatives and thus make better decisions leading up to finished services and products.

Moorby (2020) also argues for the increased use of open data in smart cities. He claims that data should be considered the "new soil in which the citizens can come and grow what they wish." While some may argue that it is overly metaphorical, it does bring over the point that data, if managed correctly in the smart city, may yield significant benefits for its citizens. Through sharing and utilizing big data and thus allowing third parties to utilize it a smart city may overcome the issues facing them of underdelivering on their promises and incorrectly claiming the "smart" label (Hollands, 2008; Moorby, 2020).

One example of open data strategies is Norway is Trondheim which has a goal of opening up as much data as possible (Ahlers et al., 2019). Another example of such strategies in the Nordics is Open data DK which is an initiative by 42 Danish municipalities. Through an Open Data portal 915 different datasets are available. A total of 289 of these are from Copenhagen municipality and range from topics such as transport, education, environment, energy and the economy. Most datasets are also available in many different formats, which increases the re-usability of the data (Abella et al., 2017). With such a large repository of data, the use areas are limitless, and examples of use areas range from corona-related analysis of transport, digital assistants for large public events and online games. According to Open data DK (n.d.) the goals of the initiative is both to create transparency in public management and to create an arena for data-driven growth and innovation which is in line with current research on the topic (Abella et al., 2017; Ahlers et al., 2019; The Economist, 2016).

2.5.3 The Business model dimension

Iansiti & Levien (2004) argues that ecosystems actor needs to look beyond their own role and profitability in an ecosystem, but rather consider the health of all ecosystem actors. In short, this means that a keystone actor in an ecosystem should share some or most of the value capture with other actors in the ecosystem, since this will aid them in the long-term success of the firm. This sentiment is applied to business models and the Internet of Things by Westerlund et al. (2014) who presents a business model framework that is applied to an entire ecosystem instead of an individual firm. The framework consists of five elements. Four of them are value drivers, value extracts, value nodes and value exchanges which describe how value is created, captured and shared within an entire ecosystem. These four elements are included in an overall group called value design. The value design is synonymous to a business model on an ecosystem level and also takes part in defining the boundaries of the ecosystem. An issue with the model is it's lack of specificity making it difficult to translate into real world examples, however, it does argue in line with Iansiti & Levien (2004) in that one should act with the ecosystem in mind, and not only the firm itself.

In part building on Westerlund et al.'s (2014) Ecosystem business model, Bullinger, Neuhüttler, Nägele, & Woyke (2017) propose a business model framework for smart service ecosystems with the platform owner as the focal actor. A central theme of the article is the sharing of value capture and value creation between the different actors related to network, software, service providers and the consumers themselves. The inclusion of the consumer in both value capture and value creation is especially interesting in a Smart City and platform context where a consumer has the potential to create significant value.

In addition to the overall framework related to the value proposition Bullinger et al. (2017) proposes a process that may be used to design a service business model for the entire ecosystem. Through an initiation phase where the vaue propositions for each members is designed a profile is also made for all the actors. A central part of the profile is the pains and gains of each actor, including what creates and relieves these pains (Figure 2.2). The value proposition is furtherly developed in an ideation phase. An importan aspect of this phase is to build trust, which is important in early phases of smart city projects (Ferraris et al., 2018; Paskaleva, Cooper, Linde, Peterson, & Götz, 2015). The last phase before implementation is an integration phase with business wargames which is designed to test the viability of the business model.

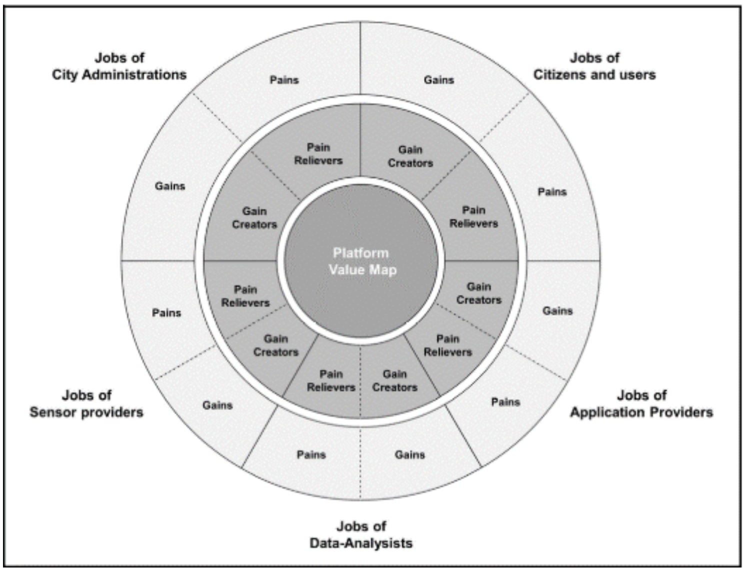


Figure 2.2: Pains and gains for ecosystem actors (Bullinger et al., 2017)

While the frameworks of Westerlund et al. (2014) and Bullinger et al. (2017) are useful, they aren't applied or formed on the basis of concrete cases. Brock, den Ouden, van der Klauw, Podoynitsyna, & Langerak (2019) contributes to the ecosystem business model research with several cases from Smart City initiatives from Philips Lighting. Through the research four business models are identified which all differs in terms of whether the value capture and value creation is done only by Philips or jointly with other ecosystem actors. The authors conclude the authors conclude that urban innovations demands collaboration with municipalities, citizens, and competitors to see lasting effects of smart city efforts.

In an Internet of Things setting the role of a Mobile Network Operator (MNO) is central because of the competence and resources related to connectivity. With the advent of 5G, Camps-Aragó, Delaere, & Ballon (2019) proposes six different 5G business models an MNO may partake in. One of these is as an ecosystem orchestrator. This is a model that yields limited power for the MNO, however, the MNO is still able to benefit significantly through its network and the services it provides through connectivity and a platform. Another model that is proposed is one of smart city ecosystems, however, here the importance of the municipality to be involved is emphasized. Because of smart city services often yielding positive externalities, it is difficult to monetize. Therefore, for it to be profitable for an MNO, a municipality must act as an intermediary on behalf of its citizens. The business models are not mutually exclusive and may also be combined with everything-as-a-service and platform type models. All in all, with 5G on the rise, MNOs will see its business models change, and will be increasingly dependent on the ecosystem to survive and thrive.

From research on business model in the field of IoT and smart cities it is clear that taking on an ecosystem view is essential. Sharing the benefits and costs between the different ecosystem actors ensures the health of the ecosystem in line with Iansiti & Levien (2004). Furthermore, choosing such a strategy can attract new promising firms to be a part of the ecosystem which is vital in early stages of an ecosystem (Moore, 1993).

2.5.4 Helix model of innovation

The public-private partnerships discussed are an important area for innovation (Ferraris et al., 2018), however, in many cases it is not sufficient to describe the parties driving innovation in today's society. The triple helix model of innovation is used to describe how government, industry and academia together drive innovation and economic growth (Etzkowitz & Leydesdorff, 2000). In the field of smart cities and other digitalization efforts in municipalities, the role of the university is related to knowledge and competence. Ardito, Ferraris, Messeni Petruzzelli, Bresciani, & Del Giudice (2019) proposes four different roles of the university in such collaborations:

- Knowledge intermediaries – Where the university works as intermediaries between public and private parties.
- Knowledge gatekeepers – The university acts as gatekeepers, meaning that they connect project partners with other existing partners and ecosystems.
- Knowledge providers – The university also provides technical and scientific knowledge through their research.
- Knowledge evaluators – By leveraging their high absorptive capacity, the university also acts as evaluators of external knowledge.

Through taking on these roles, the university may take part in solving issues arising in public-private partnerships such as the publics low absorptive capacity(knowledge) and the firms reluctance to share knowledge (Scuotto et al., 2016). Other benefits for including universities are that they could increase citizen engagement and connect external actors to a project (Ardito et al., 2019). Lastly, a university may play an important role in reconciling public-private conflicts through acting as an intermediary between the private and public actor (Ardito et al., 2019; Scuotto et al., 2016).

Competence and knowledge being the key resources of a university, they are in some ways in competition with consulting firms whose knowledge leadership is their main value offering (Etzkowitz & Leydesdorff, 2000). They can act both as intermediaries and solve some of the public-private conflicts as suggested by Scuotto et al. (2016), or they can take on the role as knowledge providers and solve a specific customers problem as suggested by Etzkowitz & Leydesdorff (2000). However, while the consulting has the capability to take on some of the roles of the university they lack continuity and the capability to pursue and manage large research programs (Etzkowitz & Leydesdorff, 2000). In summary, the consulting firm may play an important role, but it is far from outplaying the relevance of universities in triple helix collaborations.

The triple Helix framework and the expanded helix frameworks has been extensively applied to the field of IoT and smart cities (Appio, Lima, & Paroutis, 2019). Nesse, Hallingby, Erdal, & Evjemo (2020) sees the outline of a triple helix ecosystem in the a part of Norway where an MNO plays an important role. Through IoT and AI labs in the city where the MNO, an academic institution and startups are involved we can see an outline of helix type innovation models in practice. Furthermore, in Chang, Mikalsen, Nesse, & Erdal's (2020) study of Norwegian municipalities they found that helix strategies were very common among Norwegian municipalities, including quadruple and quintuple helix strategies based on Carayannis et al.'s (2018) framework with citizens and the environment being included as the fourth and fifth helixes, respectively. This research does imply that innovation in the field of IoT and digitalization is aided by triple helix type collaborations.

Including citizens as the fourth helix in a helix model of innovation is a well known concept with many benefits (Carayannis et al., 2018). In the field of smart cities this is often done as a "living lab" which is a term for an arena were citizens can take part in contributing towards developing smart city services. Schaffers et al. (2011) argue strongly for the use of Living labs, although, in their research it is not discussed as a part of a helix model framework but rather an expanded public-private partnership called public-private-people partnership(4P). By relying on citizens in a co-creation process through a living lab one can better align the technology push and application pull and thus find breakthrough ideas (Schaffers et al., 2011).

Paskaleva, Cooper, Linde, Peterson, & Götz' (2015) research seeks to figure out what makes these living labs actually work. Out of many findings, one is that the opportunities in a living lab is not well known and that increased citizen involvement may lead to significant benefits. They also found that trust building is an important activity in managing citizens in a living lab, preferably as non-intrusive as possible through face-to-face meetings. Furthermore, ensuring that the users has a proper incentive and shares the common goal of the living lab is key. Lastly, they distinguish between citizen involvement, which is citizens being used as testers to see if technology actually works, and citizen engagement, where the citizens are regarded as co-developers that significantly contributes to the innovation process. The latter is essential to achieve the goal of a living lab which is not to simply test new solutions, but to create them (Schaffers et al., 2011).

Hosseini et al. (2018) presents a case of user engagement in a "smart town" project. Through early involvement of citizens, the context in which new solutions must work will be better understood. Furthermore, engaging citizens in making new ideas through workshops led to several ideas that in themselves were not ground-breaking, but in the context of the small town would be a significant improvement to current services. In general, Hosseini et al. (2018) argues that a key benefit of engaging citizens is related to the context in which new technology will be used. This is in line with other research on living labs and citizen involvements and highlights the key contribution of the citizens in a helix model (Paskaleva et al., 2015; Schaffers et al., 2011).

2.6 Innovation in IoT and Smart cities

Explorative and exploitative innovation efforts are different in nature and is affected by, and affects the organisational composition (March, 1991). Within the field of smart cities, Ferraris et al. (2018) find several characteristics of the two modes of innovation in terms of the organisation of public-private partnerships. Explorative projects see little risk sharing with municipalities and is normally managed by the private partner. Still, the governance is flexible and knowledge sharing tend to be more open which indicates that there is room for the municipality to have a deeper involvement. In exploitative projects, the risks and management responsibility are shared between the parties. In terms of knowledge sharing a closed approach is more normal, which is natural since these projects involve more mature technology which a firm would like to benefit from in the markets themselves.

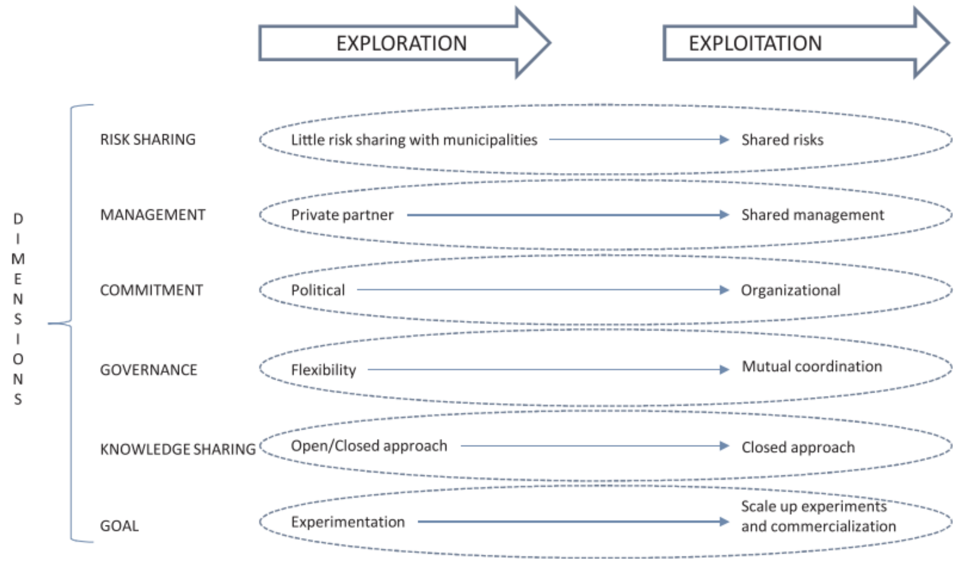


Figure 2.3 Six dimensions that vary between explorative and exploitative projects in PPPs in smart cities (Ferraris et al., 2018).

In addition to Ferraris et al. (2018), Nielsen, Baer, & Lindkvist (2019) expands on the organisational peculiarities of explorative and exploitative municipal projects. Their finding indicates that what is initially explorative projects with new and ground-breaking ideas is gradually evolving into more and more exploitative projects as time goes by. The reasoning for this is related to risk-adversity in the municipality, unsuitable governance structure for explorative projects and incentives that doesn't match the goals of explorative projects. Beyond this, it may also indicate a lack of management capabilities of explorative projects within the municipality, which coincides with Ferraris et al. (2018) finding that explorative projects are managed by private parties.

There is additional support in theory that management capabilities are a barrier for innovation in municipal smart city projects. Ferraris, Santoro, & Pellicelli (2020) seeks to identify the barriers for municipalities to partake and succeed in open innovation efforts with citizens and other stakeholders in a city. In addition to issues with the management of a municipality, disincentives, rigid procurement rules and lack of technological capabilities are identified as barriers. This goes to show, that while many benefits can be gained from open innovation in smart cities (Schaffers et al., 2011), it does not come without issues.

A typology of innovation that is asynchronous to the explorative-exploitative axis is Nilssen's (2019) typology ranking smart urban innovations from incremental to radical. According to her, radical innovations are often conceived from PPPs and triple helix collaborations. On the other hand, technological and intra-organisational efforts tend to be more incremental in nature.

The topic of Open Innovation is also discussed extensively in the field of IoT and smart cities (Ahlers et al., 2019; Bullinger et al., 2017; Hosseini et al., 2018). In addition to those previously mentioned (Santoro, Vrontis, Thrassou, & Dezi, 2018) discusses open innovation in the light of knowledge management and IoT. Through their findings they see that knowledge management systems, which is defined as IoT and ICT systems, is positively correlated with open innovation practices in a firm. Furthermore, open innovation leads to a higher knowledge management capacity which again leads to a higher innovation capacity. This indicates that open innovation practices is a good way of increasing the competences innovativeness of a firm, especially when combined with IoT and ICT systems.

In conclusion, for municipalities that wants to see radical and explorative innovations must find parties to collaborate with outside their own organisation. Involving citizens through living labs may lead to ground-breaking innovations with more promise in the city (Paskaleva et al., 2015; Schaffers et al., 2011), involving academic and private actors in innovation will lead to more radical innovations (Nilssen, 2019) and seeking capabilities from outside the municipality will allow one to overcome the barriers for open innovation (Ferraris et al., 2020).

2.7 Digitalization in Norwegian municpalities – and current challenges

With Norwegian municipalities having a potential of saving 100 billion NOK by 2028 through digitalization (Mellbye & Gierløff, 2018), the field is important for policy makers, municipality representatives and the private sector delivering solutions to them. One measure of the current state of digitalization can be found in the DESI index by the European Commission (EC, 2019). In the report, which also includes Norway, Norway is ranked as number five, only slightly below Sweden, Finland, Netherlands and Denmark and outranking 24 other EU countries. This indicates that the state of digitalization in Norway is very good in an international context.

A report by the Statistical Central Bureau related to digitalization by Norwegian municipalities elaborates on the state of digitalization in Norway today with data on all municipalities. While the state of digitalization is very good in Norway according to the DESI Index, there is still a massive potential in digitalization in Norwegian municipalities (Mellbye & Gierløff, 2018). However, there are barriers that needs to be overcome to bring out this potential. In particular, the lack of competence in Norwegian municipalities is a large barrier for digitalization in 42% of municipalities and for municipalities supplying their own IT-functions, this issue is especially prevalent. The issue of competence is linked to recruiting, which is challenging for most municipalities, especially those around Oslo, however, the municipalities who struggles the most with the competence level has made the least attempt at recruiting IT specialists. While no conclusions are made from the report, one can speculate that the issue is just as much related to lack of trying, instead of lack of supply.

To understand the potential in digitalization of municipalities Mellbye & Gierløff (2018) divides the operating cost of Norwegian municipalities in three nearly equal parts.

1. Administration, property management and others
2. Schools and kindergartens
3. Health services

The first category relates to digital services for citizens and tourists (Hosseini et al., 2018; Rybalka et al., 2019; Schaffers et al., 2011), surveillance of property and smart water grids (Farmanbar et al., 2019) and similar activities. In general, most smart city initiatives seems to relate the most to this operating area in the municipality. In terms of benefits, 42% of the potential benefits in a municipality comes from this area (Mellbye & Gierløff, 2018). The second is mainly related to teaching and such and only 13% of benefits come from this area. Lastly, the health services area accounts for 46% of potential benefits. The high potential of digitalization in health services is reflected in how many articles related to the field that has been found in theory.

Use of welfare technology is expected to increase drastically in the coming years with the population becoming increasingly older (Holthe et al., 2017). A key goal of using welfare technology is to allow older people to live longer at home and thus saving municipalities and the public health sector for the large costs of elderly care homes. This alongside more effective work processes may allow for 46 billion NOK to be saved for Norwegian municipalities, or even more if the more optimistic scenarios of Mellbye & Gierløff (2018) is fulfilled.

The implementation of welfare technology does not come without challenges (Holthe et al., 2017). In particular, the effect new technology has on an organisation is a recurring topic (Holthe et al., 2017; Lo et al., 2019). Lo et al. (2019) recognizes the large effect digitalization may have on an organisation through what is known as the "20% technology - 80% process"-rule, which indicates that implementation of new technology is mostly about the organisation and little about the technology. Proper anchoring and awareness of the potential of technology is important in overcoming this challenge (Holthe et al., 2017). Furthermore, a lack competence is considered a challenge and relates a great deal to the organisational issues to implementing new technology (Holthe et al., 2017). In addition to proper anchoring, this calls for more training and education of personnel throughout the organisation.

In a Swedish study, which is a context arguably similar to the Norwegian context based on cultural distance and DESI ranking, it was found that the digitalization transformation was too slow in elder care homes according to employees (Baudin, Gustafsson, & Frennert, 2020). This was especially evident among younger participants in the study or those with a short career. The degree of exploration of welfare technology was also studied, and although it was strongly encouraged by most managers, very few employees in all age groups did it to any significant degree.

All over, welfare technology is an important area for municipalities looking for cost savings and improved lives for citizens. The strategies of obtaining these benefits is in many ways similar to the ones of smart cities and general municipal administration. Among others, the sharing and availability of data is an area with untapped potential (Østbye, 2020). The untapped potential of open data probably relates to the increased demands of privacy and security in the health sector compared to other areas of municipal operations.

In analysing digitalization in Norwegian municipalities, it is important to understand how diverse municipalities are. The main characteristic that is important to have in mind is the size of the municipality. According to Rybalka et al., (2019) there are several small municipalities who has no ICT projects in the pipeline, indicating a lower level of digitalization. Furthermore Mellbye & Gierløff (2018) states that small municipalities are lagging behind on digitalization. An important reasoning for such a disparity is the small economies of scale of digital solutions in small municipalities and towns (Hosseini et al., 2018).

All in all, Norway is doing very well when it comes to digitalization in the public sector according to the DESI Index, however there are some issues. One interesting aspect in SSBs report is that municipalities are offering less services digitally compared to that of their suppliers. This could be considered an indication that the digitalization status in the municipal sector is worse off than in the private sector. Kvaløy & Mohn (2018) may have identified a reasoning for this disparity in their study of incentives in the public sector. In short, the productivity growth in the public sector is much worse than in the private sector and the authors see this in the light of the incentives (or lack thereof) in the public sector. With little incentives to increase productivity, managers may be less inclined to initiate needed digitalization projects. While the study of Kvaløy & Mohn (2018) does show some issues in the public sector, it does also show that the public sector should have significant potential for productivity improvements which should be a motivation to implement further digitalization projects.

2.8 Barriers identified in the digitalization of municipalites

As we have seen, there is a huge potential in digitalizing Norwegian municipalities. However, as is implied by RQ2 realizing this potential is not done without overcoming some barriers. Many such barriers are identified in theory, both explicitly and implicitly. One of the more explicit research into the theme is Ferraris et al. (2020) who look into the barriers for openness in public organizations in smart city projects. The focus of the paper is to a large degree similar to this paper; however, the context is different with Ferraris et al. (2020) being focused on large smart city projects and limiting the paper to look at municipal barriers to partake in open innovation activities. The main barriers identified in the paper are:

- Lack of rules, tasks and responsibility
- Insufficiently integrated view of the city planning
- Lack of fit of administrative styles and inter-departmental coordination and communication
- Risk-aversion
- Data availability
- Disincentives and non-flexible public procurement rules
- Lack of resources
- Lack of technological capabilities

Numerous other issues arising in the relationships between public and private parties has been mentioned before. One such barrier is the private party's worry related to IP rights which is found to be an issue by both Scuotto et al. (2016) and Ferraris et al. (2018). A passive role of municipal representatives along with scarce managerial capabilities is another characteristic of municipalities that could create issues in public-private partnerships (Scuotto et al., 2016).

Another area mentioned by many scholars is the lack of competence in municipalities and a low absorptive capacity. The lack of competence, or technical capabilities that Ferraris et al. (2020) refer to them as, is an issue confirmed by SSB (SSB, 2020), as well as other sources(Ardito et al., 2019; Chang et al., 2020; Ferraris et al., 2018; Scuotto et al., 2016). Some of this lack of competence is also related to ICT security which is a type of competence lacking both in the public and private sector in Norway (Mark, Tømte, Næss, & Røsdal, 2019). The lack of competence can in part be mitigated by bringing in competence from the outside. Rybalka et al. (2019) imply this since the municipalities relying on private actors in their digitalization projects experience the lack of competence as a smaller barrier than those who attempt to handle it internally. Furthermore, the university could play a role in mitigating low competence levels and absorptive capacity in the municipality (Ardito et al., 2019).

In addition to research looking at the collaborative barriers for smart city innovations, statistics are available for barriers the development of digital services in municipalities (SSB, 2020). The statistics are based on self-reporting from municipalities and they show that the biggest issue is freeing up resources. Several other issues are related to lack of standards, common public infrastructure and integration with existing ICT systems. There are also issues related to cost and lack of competence in the municipality. Just as interesting as the most common barriers are the least common. Legislative, political and lack of involvement from leaderships are barriers experienced by less than 20% of the respondents. Interestingly enough, these areas are mentioned as barriers by Ferraris et al. (2020) which does show that not all research and statistics are unanimous in terms of what barriers are the most significant. The full list of barriers by SSB is summarized in Table 2.1 below.

Table 2.1: Barriers for development of digital services in the municipality (SSB, 2020)

Difficulties of freeing up resources	74,8%
Dependency of development in other organizations	58,5%
Lack of common public solutions and infrastructure	50,2%
Difficulties of integrating with existing ICT systems	46,8%
Lack of competence in the municipality	45,8%
Lack of common standards for data exchange	44,9%
ICT-costs higher than expected	43,4%
Lack of political guidelines	14,5%
Lack of involvement from leadership	12,6%
Legislation and rules lack fit	19,1%

Chang et al. (2020) also touch on the topic of barriers for digitalization. They found that issues from the lack of existing technologies were non-existent. However, what they did find was that lack of competencies in the municipality was an issue and that they were reluctant to start digitalization projects without knowing the benefits beforehand. Another issue they found was the lack of Open APIs and practices that could lead to a lock-in effect with certain suppliers.

There are numerous barriers for digitalization and innovation mentioned in theory. One of the more significant is the lack of competence. Beyond this, other organisational issues are mentioned such as issues with freeing up resources. Furthermore, disincentives and risk-aversity is a potential barrier, especially related to innovative projects (Ferraris et al., 2020; Kvaløy & Mohn, 2018). Other barriers relate to the lack of open standards, which in part is explained by theory on platform ecosystems. In conclusions, there are many barriers for innovation and digitalization, but there are also significant benefits if one can overcome them.

3 Methodology

3.1 Litterature

The literature review was conducted with the goal of getting an overview of current research related to the research question. The guiding principles for the literature review is based on Denyer & Tranfield's (2008) principles for conducting a systematic review. According to them the principles for conducting a systematic review in management and organization studies is transparency, inclusivity, explanatory and heuristic nature.

Based on these principles, the literature review will not be replicable, however it will be outlined below what choices have been taken. Thus, the goal is that the review process will be transparent so that the reader may understand and consider the scope of the review as well as the ways in which the review may have been affected by the authors bias.

3.1.1 Literature collection

In total two database searches were conducted as well as a snowballing procedure to expand the list of relevant literature. The methodology is summarized in Figure 3.1.

For the literature collection Scopus was the main source of data. While Google Scholar includes more citations, Scopus is usually restricted to mostly include results from journals (Martín-Martín, Orduna-Malea, Thelwall, & Delgado López-Cózar, 2018), which is a useful trait for narrowing down the results. Furthermore, Scopus includes more tools which allows more options to reduce the sample size when it is deemed necessary.

The first database search done with keywords related to innovation and internet of things in the public sector. "Smart city" was also included as a possible keyword instead of "internet of things" and municipality related keywords. Initially this resulted in 750 articles being returned which was deemed to excessive. To further limit the search, "Ecosystem" was added as a keyword which limited the results to 183 documents. The full set of keywords is summarized in Table 3.1: Database search 1 - Keywords selected for first literature search. The two searches were conducted as one search by the use of AND/OR operators and therefore returned only one list of articles.

Table 3.1: Database search 1 - Keywords selected for first literature search

Smart City	Ecosystem	Innovation Co-innovation Co-creation

Internet of Things	Municipality City Public sector	Ecosystem	Innovation Co-innovation Co-creation

The search algorithm used in Scopus:

TITLE-ABS-KEY ("smart city" OR ("internet of things" AND ("Municipality" OR "city" OR "public sector"))) AND TITLE-ABS-KEY ("ecosystem") AND TITLE-ABS-KEY (innovation OR "Co-innovation" OR "Co-creation")

All titles and abstracts of the 183 results were examined which resulted in a selection of X articles being made. The selection of the articles was done based on their relevance to the research question meaning that they should be strongly related to two themes:

- Public private partnerships or collaborations related to the triple helix model.
- Digitalization or use of Internet of things in public sector, preferably municipalities or cities.

A second search was conducted in Norwegian. The reasoning for this is that important characteristics of Norwegian municipalities, laws, culture etc. is likely to affect the innovation efforts towards municipalities. Because of the more limited amount of research published in Norwegian on most topics compared to English, the search was made to include all research on digitalization and IoT in municipalities and the public sector.

Table 3.2: Database search 2 - Keywords selected for second literature search

Internet of Things IoT Digitalisering	Kommune Kommunal Offentlig sektor

The search was conducted in the Oria database, since Scopus doesn't include research in Norwegian. Initially 216 results were returned, but by limiting the results to only be from peer reviewed journals 65 articles were left. All abstracts were read and in total 7 articles were selected for further review.

3.1.2 Snowballing

During the review phase of the selected articles references that were of interest were included in the review. Snowballed articles were found either through the references in text of the articles or through a review of the reference lists. Not all articles have been thoroughly reviewed for relevant sources, but rather the ones that were the most relevant for the research questions were given extra attention. From all the chosen articles a total of 17 articles were found through snowballing.

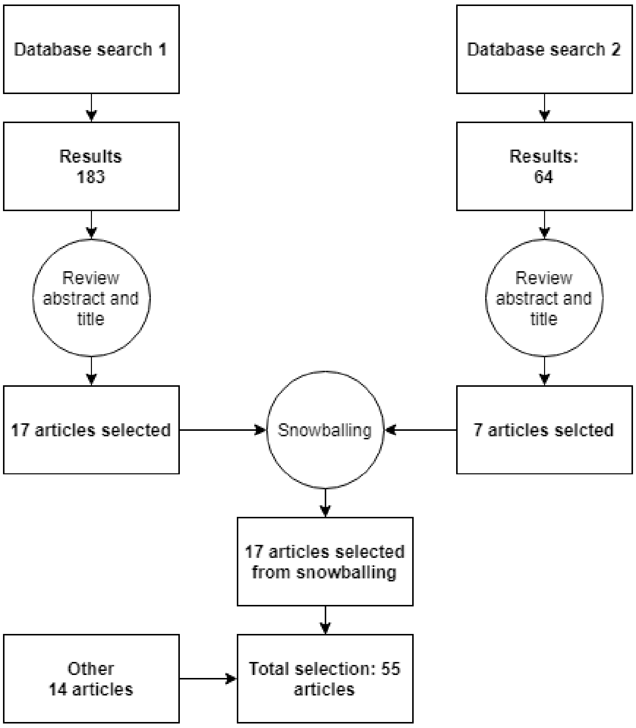


Figure 3.1: Overview of literature collection.

3.1.3 Synthesizing and presenting the litterature

Throughout the review of the literature the articles were synthesized and categorized. The categorization was the basis for the structure of the literature section where the topics of interested to the research questions was outlined and presented.

3.2 Empirical data collection and analysis

Table 3.3 Overview of data sources

Primary data	4 Interviews with municipal representatives 4 Interviews with representatives for private actors 1 Interview with an academic representative
Secondary data	Statistics and reports from SSB Report on smart municipalities Websites related to the cases from the interviews.

3.2.1 Selection of informants

The selection of informants was done through the network of the author, recommendations from the informants as well as with the aid of other third parties. An emphasis was made to have the informants both from the private and public sector. A representative from academia was also interviewed to expand the data to also consider the university perspective from the triple helix framework. An overview of the interviewees is presented below in Table 2.1 with info on each informant and Figure 3.2 detailing connections between different actors. Actors being connected generally mean that they have insight into and have discussed the opposite actors and their relation to them actively in interviews.

Table 3.4 Overview of informants.

	Name	Type of actor	Description
P1	Welfare technology spin-off	Welfare	A long-time supplier to the public sector that has started developing an Internet of Things solution for the health sector. Development of the solution has been done in collaboration with several municipalities and has led to a spin-off firm being founded.
P2	Water Service Supplier	Water Services	A long-time supplier to the municipal water service sector. Through a large initiative to digitalize their products and offer surveillance of water systems as a service they are developing IoT solutions through their ecosystem in close collaboration with a municipality.
P3	IoT consultant	Consulting	A consulting company working specifically towards consulting IoT projects. Through having municipalities as customers as well as being involved in the welfare-technology spin-off, they have insight into the challenges related to innovation in municipalities.
P4	Mobile Network Operator (MNO)	Connectivity	The MNO is a leading supplier for IoT companies through connectivity, but also advisory to a certain extent. They work actively towards municipalities through seminars, innovation programs and indirectly through the value chains of other companies.
M1	Municipality 1	Municipality	A waste management company owned by multiple municipalities. They are utilizing some Proof-of-concept IoT solutions and is partaking in a university research project.
M2	Municipality 2	Municipality	One of the municipal divisions is partaking in an IoT project by the MNO. The municipality are attempting to find new use cases for IoT technology.
M3	Municipality 3	Municipality	One municipal divisions is testing a Proof-of-Concept of an IoT solution aided by their LORA network. Through surveillance of their water network they wish to reduce water leakage
M4	Municipality 4	Municipality	The municipality has several IoT initiatives and digitalization projects. They are taking part in an extensive university collaboration program.
A1	Academia representative	Academia	A leading representative from an academic institution with involvement in a local smart city project. Was involved in the project making smarter waste management solutions in.

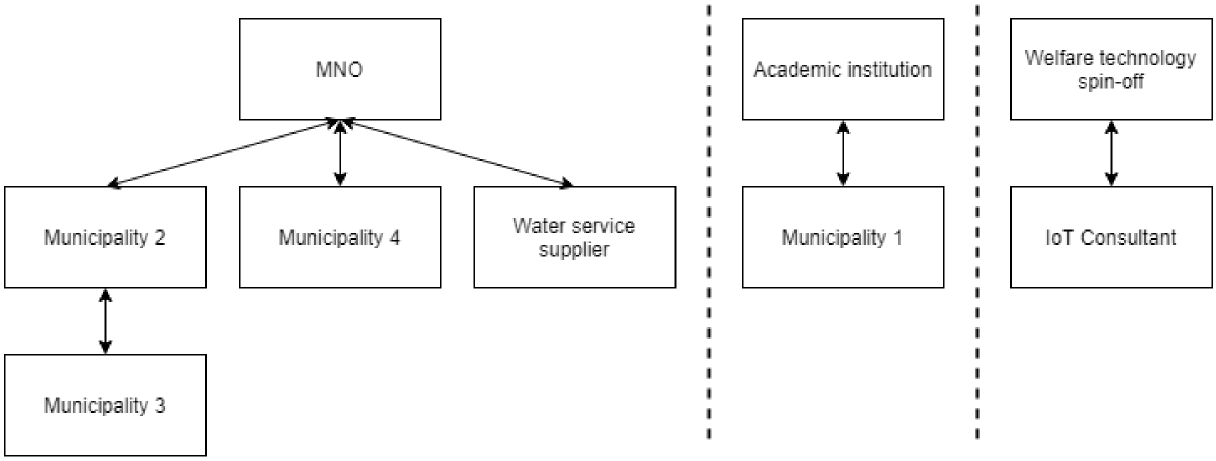
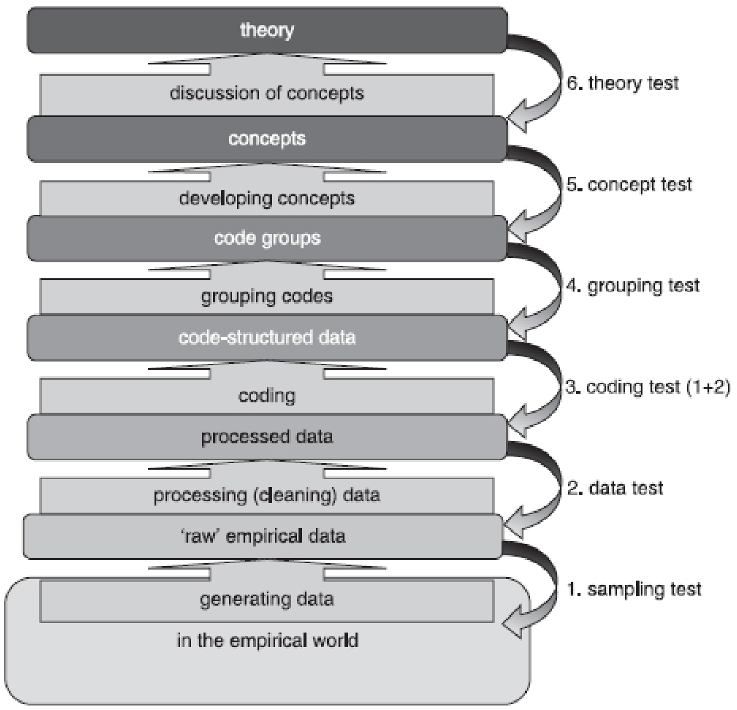


Figure 3.2: Overview of connections between the different informants. An arrow indicates that the interviewee can act as an informant on one of the other cases.

3.2.2 Framework for collecting and analyzing data

The analysis of the empirical material is based on Tjora's (2018) method from *Qualitative research as stepwise-deductive induction*. The method describes the process from generating data to creating new theoretical concepts. Every stage consists of some analytical activity and a subsequent test of the findings. An important aspect of the method is that it allows you to analyze the empirical material without letting theory limit the topics of potential findings. However, in the later stages of the process is tested towards theory both to assert relevance as well as potential contradicting findings.



3.2.3 Generating and processing raw data

Interview lasted from 39 minutes to 78 minutes and was conducted from February 2020 to April 2020. Most interviews were conducted on Microsoft Teams or phone because of social distancing rules and large geographical distances to the informants. All interviews were digitally recorded and transcribed. Alongside the interview process websites of informants as well as other sources referencing the cases in question were examined, thus increasing the validity of results where secondary information sources were available. As the interview and transcription process were coming to an end coding was started.

3.2.4 Data analysis

The interview transcriptions were imported to nVivo 12 for coding. The coding was done as empirically close coding, meaning that the codes themselves should reflect the meaning of the empirical material (Tjora, 2018). Through this method the codes themselves act as a condensed version of the empirical data which eases the work of processing and analyzing the data. In total this resulted in 441 codes. The codes were grouped in 10 different groups, in addition to a "reject" group. 6 of the groups were considered relevant for the RQs and was analyzed carefully and are highlighted in bold text. Remaining groups were either quite small or deemed irrelevant, however, they were kept as they were for a potential revisiting if a certain theme was brought up through other means at a later stage.

Table 3.5 Code group and examples of empirically close codes within each group.

Code group	**Items**	**Examples of codes**
Barriers	69 items	Codes are summarized in **Error! Reference source not found.**.
Learning and competence	53 items	• People don't know what IoT solutions exists • IoT is completely new for the firm • Need for dedicated IT-personnel
Possibilities and enablers of digitalization	59 items	• IoT leads to sustainability • Would like an economic benefit of IoT • Lack of insight is an issue and IoT can solve that
Organizational structure	48 items	• The program was anchored with our owners • E-policy, security measures and routines creates frustration in the municipality • Interviewee is a driving force for IoT project
Collaboration	105 items	• The CEO has coordinated the external partners • [firm] is a partner in Smart City • The municipality contributes with difficulties and use case ideas for the technology • Students at a university studied elders resistance to new technology
Verticals and ecosystems	50 items	• Closed platforms not wanted by the municipality • Many verticals within the municipal division • To have industry standards and products that all work on the LORA network is important
Technology	35 items	• There is large capacity in the LORA network • 5G and NB-IoT reaches places with bad coverage

		• No IoT platforms in the market are good enough
Procurement processes	20 items	• Procurement processes are challenging • Tenders inhibits innovative processes • Tenders inhibits innovations and increases costs
Business models	11 items	• IoT changes business models • Large potential for growth
Security and privacy	7 items	• Privacy issues with open data • Security and privacy is important • Security is not a worry
Process	12 items	• Simple prototypes is important in an early phase • Digital competence is needed at every step.
Reject	34 items	

There were some difficulties experienced in the grouping phase. First of all, finding appropriate groups were difficult since many codes could belong in several different groups. In some cases, this led to some codes being added to multiple groups, however, attempts were made to limit overlap as much as possible. One area where overlap was accepted were in the "Barriers" category since most of these nodes were easily placed in a general category as well as the barrier category. The work was complicated further by trying to include a wide variety of codes as to not allow any interesting phenomenons go below the radar. Because of this, many codes were deemed irrelevant or even when if relevant, they were hard to place in one of the existing groups.

3.2.5 Concept creation

After the grouping step, Tjora (2018) proposes working with concept creation which is a fairly creative process. Through using different frameworks and matrixes the empirical material could be condensed down to easily understandable concepts. The concepts themselves are usually not created from theory but should rather emerge from the empirical material. This allows new concepts that may contradict known theory to more easily be recognized. However, even though theory usually shouldn't have a big impact on the concept creation, theory known by the author often has a big impact on the phenomenons that are discussed. It is also expected that the concepts created is tested towards theory to consider findings that contradict the new findings. Through a testing towards theory concepts may also be modified to be better aligned with already known theoretical concepts.

One process of concept creation was related to the barriers of digitalization. As stated, nodes in the barrier group could overlap with other groups. Through putting all barriers in a group of their own further analysis only on barriers was possible. The 69 codes were divided into 8 categories which were put together in three overall groups. Similar codes were joined together, leaving 31 different unique codes related to the barriers of digitalization. This resulted in an exhaustive list of all barriers mentioned in interviews. The list of barriers and the groupings they belonged to are summarized in Table 4.3.

3.3 Secondary data collection

In addition to the literature collection and empirical data collection secondary data was collected from different governmental organisations such as the statistical central bureau of Norway (SSB). In addition to this, websites and reports shared by the informants were studied to verify results and to gain deeper insights into the cases and the general condition of digitalization in Norwegian municipalities. In addition to this, to validate and expand on the data from the interviews, websites and other publicly available information has been reviewed.

3.4 Limitations of methodology

3.4.1 Snowballing procedure

Many of the articles chosen through snowballing were known by the author beforehand or were written by an author known through other literature. This is a potential source of bias in the selection of literature. On the other hand, the articles chosen through snowballing where this applies is a quite small number in comparison to the total number of articles in the selection.

3.4.2 Informant selection

An argument that the selection of informants is not ideal can be made on the basis that they are too different. Since the representatives is from so many different organisations and firms finding common experiences from the representatives may be difficult. However, it may be considered a strength, since potential findings that is common throughout the ecosystem holds greater weight than findings from only one perspective.

3.4.3 Keyword selection

Considering how central the theme of collaboration with private actors is in this review, possible improvement to the literature review would be to include "Public-private partnerships" in some of the literature searches. Since this was not included, key articles related to the themes discussed in this paper may have been missed. Still, there is arguably still a large relevant selection of articles and through snowballing of the most central articles a deep insight into the theory at hand should have been adequately explored.

3.4.4 Limited newness of research question

A relatively long time after the onset of this research an article by Ferraris et al. (2020) was published with a very similar theme to that of RQ2 regarding barriers encountered in smart city projects from an open innovation perspective. A potential limitation of this review is that this research question was to a large degree answered in previous literature. On the other hand, confirming or disproving Ferraris et al.'s (2020) findings does still have value. Furthermore, considering the differing context and wider scope of this research question the review still has it's raison d'être intact.

3.4.5 Subjecitivty

Lastly, subjectivity is as in all qualitative studies also in play in this review. Existing bias and preconceptions may have impacted the findings, especially since this review is done by a lone author. To mitigate this, I have strived to use a systematic approach to data analysis and the literature review as well as relying on outside advice throughout the research process. Thus, some subjectivity is expected to have affected this review, however with the mitigative efforts the

4 Findings

4.1 Partnerships

From the empirical material 7 close partnerships were identified, 5 of which are Public-Private Partnerships in different forms. The public-private partnerships outlined in Table 4.1 are close partnerships between a municipality and a private firm where the project has been elaborated extensively on in the empirical material. All the partnerships revolve around IoT technology, either directly through implementation and development of devices or through data analysis of collected data from already installed IoT devices.

Table 4.1: Municipal partnerships from the empirical material. Only partnerships extensively discussed in the interviews are included. *Actors marked with an asterisk were the informants from each partnership.

	Public Actor	Private actor	Description
PPP1	Municipality 1*	IoT supplier	The municipality has purchased a set of IoT sensors from a foreign supplier. The use of the sensors is closely linked to a project with the academic institution (See section 4.3.2).Waste management project
PPP2	Municipality 2*	MNO	Prototyping project seeking to find new use cases for IoT technology within the municipality
PPP3	Municipality 3*	IoT connectivity provider	Water service project where IoT sensors are put to use to limit water leakages. The private actor delivers infrastructure for a LORA network and sensors from third parties.
PPP4	Municipality	Welfare technology spin-off*	Experimental project related to welfare technology where extensive testing and feedback from a municipality has been central.
PPP5	Municipality	Water service supplier*	Experimental project related to IoT use in water service. Testing has been done in collaboration with a small municipality.

PPP1 is simply a customer-supplier relationship where an inter-municipal firm has purchased a set of sensors from an IoT supplier. The devices have been installed by the municipal representative that was interviewed and has given increased insight into the state of the waste management stations in several municipalities. Being a small-scale project with a device that is very easily installed the competence level required is very low, however, if integration into existing systems is needed it would require ICT competence. While a partnership-label may be excessive to describe the relationship between the private actor and the inter-municipal firm there has been some collaboration on accessing and exporting the data which has been gathered. Also, since the project was small-scale, it did not require any public tender processes to be done, but in the case of a scale-up of the current solution that is likely to come into play. At the time of the interview, the IoT sensors were not put to use in a way that they have significantly changed the operations of the inter-municipal firm, however, the information has showed a large potential for cost savings and increased sustainability that can be done in the operations.

PPP2 was a project where a municipality was taking part in a program by an MNO where the MNO offers access to an IoT platform, connectivity and advisory, while the municipality works on finding new use areas for IoT in the municipality. The goal is to develop a new and working solution solving a problem in one of many areas in the municipality. The municipality is managing the project, although the MNOs representatives are important in terms of the advisory role they have. For the municipality the program offers an easy way into testing new IoT solutions and to learn more. In fact, the main expected benefit for the municipality was to learn more about IoT and the possibilities it has in a municipal context and potential cost savings or other benefits were seen as subordinate by the municipal representative. For the MNO the goal is similar in learning more about IoT in a municipal context as well as bringing in new customers to their platform and their network. The financing was done by the municipality, however, the price was below 100k NOK to avoid a lengthy procurement process and thus, it is not likely that the project in itself is a profitable endeavour for the MNO.

PPP3 was a partnership between municipality 3 and a connectivity provider and was largely structured as a customer-supplier partnership. The implementation of the IoT sensors and the LORAWAN which was used for connectivity was largely managed by the private party although the municipality was sharing some of the management responsibilities. While such projects are often ruled by public procurement rules, the project budget was below 100 000 NOK which is low enough that a public procurement process did not have to be done. Furthermore, since the project to a large degree was managed by the private company, little competence on IoT was required by the municipal workers although a general awareness of some of the possibilities were present. While the project was small-scale and was regarded as a pre-project of a larger initiative, the goal was still measurable cost savings and increased sustainability of the municipal infrastructure.

PPP4 is a welfare technology related project conducted in a nursery home. Having been a long-time supplier of the public health sector the company has a lot of experience of working towards nursing homes, but the field of IoT has not been explored by the firm before. The IoT offering being developed constitutes a new business model for the firm and has led to a spin-off company being founded who is working on the technology. Through a network consisting of municipalities, universities and welfare technology suppliers the private actor found a municipality to collaborate with.

The collaboration with the municipality consists of the private firm testing a prototype of the not yet launched solution in a nursing home. Through giving the private actor access to the nursing home and their daily operations the municipality gives the private actor feedback on how the solution is working as well as potential issues and improvements that can be made. The use of the technology had not yet offered any concrete benefits for the municipality, however, the private actor considers it very likely to be a customer when a finished product and service is launched. In terms of financing all is done by the private party, however, the municipality is likely to have some indirect costs in opening up and changing their operations for the private party to test their solutons

PPP5 is a water service supplier collaborating with a small municipality. The partnership is very similar to that of PPP4 even though it is in a different sector of the municipality. IoT is new for the private actor and constitutes a completely new business model for them. Having been a long-time supplier to the municipality, the private firm does have experience with working with municipalities although the IoT and ICT perspective is still quite new.

Similarly to PPP4, PPP5 relates mostly to testing of prototypes in the context they are intended to being used as well as feedback from the users. While co-funding the project was discussed with the municipality, the project ended up being funded by the private actor, although the man-hours contributed by the municipality was essential for the project. While immediate benefits of the project were not the goal, some benefits from water surveillance was given at a very early stage. In addition to this, the municipality saw benefits of good PR through using a new and innovative solution.

4.2 Ecosystems

Both PPP4 and PP5 were very similar in many different ways. One common factor was that both private actors were a keystone actor in their own little ecosystem. In the ecosystems the private actors had access to IoT platform providers, software providers, core technology providers, connectivity providers and in one of the cases a consulting company. The private actors relied heavily on the ecosystem in developing their technology and building their own competence. They were also the only private actor with any relationships with the municipality which furtherly facilitated their role as keystone in the ecosystem. The general structure of the ecosystems is summarized in the figure below.

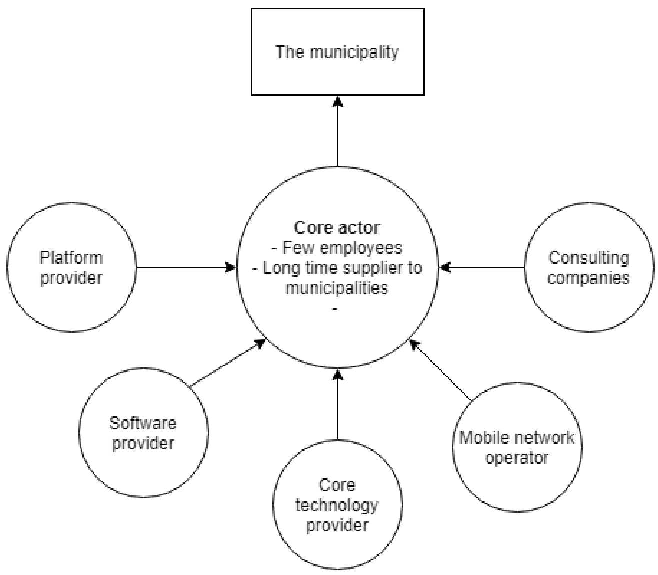


Figure 4.1 Structure of ecosystems centered around type B partnerships.

4.2.1 Forums

A common theme in the discussion of different partnerships was forums or arenas where municipalities can meet private firms or other municipalities. Such initiatives have resulted in several partnerships and digitalization projects being initiated which shows the benefit they may have. Some examples of such arenas or networks are mentioned below.

- The ten largest municipalities in Norway has a yearly meeting for one of their municipal service sectors to discuss the industry in general, including digitalization efforts.
- A large software provider for a municipal service sector has a small network of 5-6 municipalities that work together on "innovation and idea creation". This effort was central in inspiring one municipality's digitalization efforts in the water sector.
- A number of welfare technology companies, hospitals and nursing homes in one region is part of a network for welfare technology. Through this the welfare technology firm found its municipal partner in a nursing home.
- Several MNOs in Norway are doing seminars and conferences related to IoT technology. In the empirical material, such seminars have had concrete effects in a large digitalization effort in at least one municipality.
- Smart city projects and similar efforts may also be considered such a forum where municipal actors can get in touch with academia and private parties to work together on digitalization.

4.3 Collaboration with other helix actors

In addition to public-private partnership some municipalities were working closely with municipalities. There are also many sporadic university activities related to the cases, such as guest lectures, student projects and hackathons. The two close partnerships that were elaborated extensively in the empirical material are summarized in the table below.

Table 4.2 Municipal-university partnerships form the empirical material. Only partnerships extensively discussed in the interviews are included.

	Public actor	Academic actor	Description
PUP1	Municipality 4	Academic institution	A large university-municipal program with the aim of letting knowledge, technology and competence flow between the municipality and university. One of many goals of the program is to contribute to digitalization in the municipality.
PUP2	Municipality 1	Academic institution	Municipality 1 is collaborating with a university on data analytics related to their waste management IoT devices.

4.3.1 Academic-municipal project

PUP1 is an extensive municipal-academic collaboration is focused on knowledge transfer between an academic institution and two municipalities, one of which was represented among the informants. The key goal of such a collaboration between the university and the municipality is to supply the municipality with knowledge, competence and technology while also facilitating competence and knowledge flowing the other way as well. Whether or not the collaboration is deemed a success is too early to say and is likely more appropriate for larger analysis than this paper, however, in early phases of the collaboration the size of the organisations participating does create difficulties since it complicates the organisation of the partnership.

4.3.2 Waste management project

The inter-municipal waste management company (M1) and the academic representative were informants in a waste management case where IoT technology operated as an enabler for a university managed optimization project. The municipal firm offered data and access to their operations, while the representatives of the academic institution developed their optimization model based on data from IoT sensors in trucks and waste containers.

For the municipal representative the main benefit of the project was not to see cost reductions, but rather to increase their competence on those kinds of issues, so that when time comes for implementing a more commercialized solution, they have the insight to properly partake in the process. Furthermore, through working on the project they became more aware of what data was available and how to access it. All over, the research project and IoT project gave the municipal representative insight into an area with significant room for cost savings and improvements for the municipality.

4.3.3 Citizen involvment

The degree of citizen involvement was very low among the cases and thus does not seem to be a widespread phenomenon. This is in part natural since water and wastewater projects and similar areas of municipalities is mostly happening in the background, without it affecting any citizens directly. Still, some informants did emphasize the importance of user involvement, especially related to training the citizens of the municipality to effectively use technology. E.g. an iPad given to elders could be a good initiative to let elders keep in touch with families during lockdown, however, it is useless if the elders do not know how to use them. Thus, training and educating citizens to make them more technologically proficient is recognized as an important area, although actual activities doing this is lacking in this data material.

4.4 Barriers of digitalization

Through the interviews many barriers for digitalization and innovation were identified and subsequently grouped in a general and overall topic. The full list of barriers can be seen in Table 4.3 in the leftmost column. The middle and right-most column include specific groups and overall themes, respectively.

Table 4.3: Barriers of digitalization and innovation in Norwegian municipalities

Barriers	**Grouping**	**Theme**
The municipality is largely unable to finance prototyping projects Low tempo compared to private firms in innovation processes Tender processes complicate public-private partnerships The municipality is bounded by existing framework agreements.	Public procurement rules and municipal processes	Collaborative barriers
Firms are wary of sharing proprietary knowledge with municipalities Municipalities has a lack of trust to commercial actors	Lack of trust	
Lack of dedicated IT-personnel Lack of knowledge in procurement Little knowledge in ICT "Blissfully unaware" of the possibilities available through digitalization and IoT	Lack of competence	Organizational barriers
The municipality is conservative Lack of innovativeness in the municipality No one is there to inspire Risk aversity	Cultural issues	
Digitalization is 20% technology and 80% organizational change The municipality is under economical constraints Too many fragmented initiatives Lack of anchoring in the municipality Lack of incentive for municipal workers to digitalize Security policies complicating ICT implementation Slow processes for decision making	Organizational issues	
Fragmented ecosystem Current solutions is in locked down silos Lack of user acceptance of final solutions	Problems in the ecosystem	Contextual barriers
Large development and implementation costs IoT development requires a lot of time Lack of funding from municipality Large scale is needed to attain benefits	Lack of resources	
IoT is often very complex The real world is complex Uncertainty related to technology performance now and in the future The right devices and connectivity is not in the market	Technological difficulties	

4.4.1 Collaborative barriers

Public procurement rules and slow municipal processes were the most common barrier in the empirical material with nearly all informants mentioning this as an issue in their collaborations. However, while it was considered a barrier among nearly all informants, the way in which the issue materialized differed between the informants.

The tender process is described as slow both by municipal and private sector informants. For the municipal representatives it involves a fair amount of paperwork that needs to be done and rules that has to be followed. Also, most municipalities have centralized their procurement activities which leads to people outside a specialized section needing to be involved in even small digitalization projects. E.g. the ones responsible for doing large IoT acquisition related to water monitoring often has little to no experience with either water or IoT. This can potentially lengthen the process and can be a point of frustration for both private and municipal actors.

A time-consuming challenge for the private firms is to make sure that the municipalities correctly describe their product in their public tender.

> *"Yes, it is a challenge. The challenge lies primarily in making the procurement departments to go along with describing this type of equipment. […] If the tender isn't described, you won't get it"*

This process is furtherly complicated by the lack of knowledge of these solutions in the municipality.

The long procurement process has a negative effect on the private firms selling and implementing their products within the municipality. For one firm, the process from initializing the process of sales to completing and delivering it was expected to take around a year, compared to the private sector where they expected delivery immediately. In one case that the IoT consultant had insight into, a promising welfare technology product was developed and tested in Norway, but the firm chose to launch the product abroad as a direct consequence of the slow tender processes in the Norwegian public sector

The second way the barriers materialize is that the tender process often leads to suboptimal solutions being chosen long term. Through framework agreements, the procurement process of many services and products are simplified since one doesn't need to do new tender processes for each procurement. However, according to both municipal and private informants such agreements lead to municipalities being locked in for years with a supplier whose products may be both more expensive and less effective than a competitor's product. The existence of such framework agreements is especially a barrier for small niche companies, where they may have a better and cheaper product, but lack the resources to attain a framework agreement and compete with the large vendors.

Third, prototyping projects being ready for full scale implementation experiences a lot of uncertainty. For a Proof-of-concept project done in collaboration between a municipality and a private firm the full-scale implementation will still have to be put to tender, risking that a competitor may come in and take over the project. For firms that has done large initial investments in the prototypes this is a significant risk factor. On the other hand, it may be argued that the prototype themselves as well as potential testing in the municipality has provided the private actor with value that may be transferred into other markets or other municipalities.

Several ways of overcoming these barriers were mentioned by the informants. One response is to keep the total cost below 100k NOK which allows division leaders to authorize the entire procurement without going to tender. A second option is to use what is called an "innovative tender" which allows municipalities to put out a tender without a specific description of the technology itself, but rather the problems that needs to be solved (SOURCE). Then, different actors can bid on the tender and offer to develop a unique solution for the need. Lastly, simply adapting to the rules as they are and taking the time that is needed is also a way to deal with the issue of public tender processes.

Lack of trust between the municipal and private party is another issue. This has previously been shown to be an issue with private parties worrying about IP rights and proprietary knowledge when collaborating with municipalities (Scuotto, 2016). While it is a topic among the informants, it is not considered a big issue among most of them. However, at least one informant saw it fit to require all participants in a project to sign NDA's, which shows that it is at least a concern for some firms, especially those early in the development process of a new product.

In some cases, municipalities were found to have a lack of trust towards private actors, especially those with clear financial motivations. This lack of trust seems to be rooted in the lack of competence in the municipality since the lack of competence on what technology is available and what is to come leaves a municipality at the private actor's mercy to be informed. Having no way of knowing if the private actor is actually proposing the best solution all over or just their own best solution is an issue.

> *"[Private firms] wish to sell their equipment, and then it is not certain that their equipment is the best for our needs, but the best that they have […] Maybe the supplier [of IoT sensors] knows that their competitor has one that is better for us […] "*
> *- Municipal informant*

4.4.2 Organisational barriers

Lack of competence in the municipality were mentioned to be a barrier for digitalization and innovation by nearly all interviewees. Part of the competence issues is related to organizational issues, like lack of IT-personnel in certain departments where digitalization processes are happening. This often leaves people with limited knowledge of ICT in charge of running the projects or handling the procurement aspect in the procurement departments. In addition to this the knowledge of the possibilities that has arisen in recent years through IoT is unknown to municipal workers throughout the organization. One quote by a municipal representative related to the barriers for digitalization was as such:

> *"I believe, that for our part, the greatest challenge is that we are blissfully unaware of the opportunities [in digitalization] that lays ahead."*

A positive side of this issue is that most municipalities seems to recognize that a lack of competence is an issue. An eagerness to learn was especially prevalent in the projects managed by municipalities, which is good for future digitalization processes there.

Cultural issues is another barrier, which in some areas are closely linked to competence. Several informants described the municipality and the different divisions as "conservative". In addition to this, the municipality was described as lacking innovativeness and creativeness. To resolve this, recruiting younger people is seemed as essential in renewing the different industries in the municipalities. One informant emphasized the importance of collaborating with universities to create awareness and recruit young creative people to the different sectors.

Organizational issues were brought up in some forms by most informants. The difficulties that arose can be divided mainly in to two groups. First is a lack of anchoring and co-ordination of different digitalization initiatives. Oftentimes IoT projects are small-scale and happening in smaller parts of the different municipal divisions. This results in solutions built on very different technology which leads to issues down the road with systems speaking to each other. It also leads to competence on IoT and digital solutions only being present in some parts of the organization and not in others. One municipal informant summarizes it well with:

> *"I believe the greatest challenge is that we don't have anyone in the driver seat saying that [our municipality] municipality is going to become something. Some things are done here and there, but it is not co-ordinated, and that is very sad. […] we should have brought some chiefs inn that could really take a hold of it and say "lets do this"*
> *-Municipal informant*

The second issue related to organisations is slow processes and simply that things take time in the municipality. This is closely connected to the issues related to collaboration with other parties referenced in section 4.4.1 as well as the issue of public procurement rules, however, it is included here to specify that this also relates to purely intra-organizational processes.

Third, challenges related to the change experienced in an organisation is also a barrier. The story of digitalization being 20% technology and 80% organisation rings true in the empirical material as well as theory (Lo et al., 2019). Again, a link to competence is found also in this area, where the lack of competence often what is creating some of the issues with change the organisation and processes.

The municipal representatives were wary of taking on too much risk in experimental projects. Reasons for being risk-averse was respect for the citizens money as well as political considerations. The risk-averse behaviour of the municipalities is mitigated by private actors being willing to take on much of the risk. In particular, in the Welfare Technology Spin-off and the Water Service Provider cases the private firms took the entire financial risk, while the municipality mainly offered them access to the municipalities water infrastructure and nursing home.

The fear of losing the citizens money and receiving media exposure is one area causing risk-aversity. A second area, which was mentioned by private informants was a lack of incentives to digitalize. This was mainly attributed to the fact that municipalities has no competitors and losing money will not cause the organization to disappear as is the case in the private sector. Because of that, municipalities may be far slower than private firms where digitalization is do or die.

4.4.3 Contextual barriers

Three key areas of contextual barriers were identified. First, problems related to the ecosystem is one area where issues with end-users and fragmentation of the ecosystem can be an issue. Furthermore, a mismatch between resources available and the time that it takes to develop and implement IoT solutions is another area. Lastly, technological difficulties related to new and old technology may create issues.

Ecosystem related problems, especially the ecosystem being fragmented with many proprietary technologies is a potential issue in the field of IoT. The issue materializes in three ways. First, the end-user experiences that different systems don't talk to each other and that a lot of equipment and software is needed instead of having all information available one place. Second, implementing solutions when a municipality is already locked into some proprietary technology is much more problematic compared to when systems are built on open standards. Lastly, accessing data when it is locked down in a whole set of different systems and in different standards is difficult and was in some way an issue for three out of the four municipal informants. All over, this issue is both related to the collaboration (or lack thereof) in the ecosystem as well as the results this has in the technological sphere.

The Welfare Technology Spin-off summarizes the issue and relates the issue of proprietary technology to the fragmented ecosystem:

> *"What could become a barrier or a challenge is that there are a lot of different welfare technology that is being developed… There is not an established ecosystem. That could be a challenge as time goes by. […] The worst that could happen is that we have a lot of IoT equipment in your home, but that you need a rack on the wall with 20 boxes, all on proprietary systems. And 20 of those boxes where some is on cellular and some on WiFi"*
> *- Welfare Technology Spin-off*

The cost of IoT technology is another barrier which relates to the economic aspect of IoT and digitalization. First, IoT technology is expensive to develop and implement. The high costs are related both to the technology itself as well as the scale needed in IoT solutions before they yield significant benefits. For example, for the optimization project done by the waste management company, a huge number of sensors, all with connectivity and batteries needs to be implemented for all relevant data to become available. Second, budgetary constraints were brought up as a barrier in the municipality by several parties, however, this seems to wary a lot between different municipalities because of large differences in municipal economies.

Lastly, **technological difficulties** related to IoT is a barrier that is encountered by many municipalities. First of all, IoT is often very complex technology that needs to be implemented in a complex world. There is also the need for large scale of implemented technology for it to be beneficial for the municipality and the private actor since the unit costs of connectivity and the devices is low, and stand-alone sensors seldomly gives any benefits worth mentioning. All of this takes part in driving up costs of such projects. Second, a lack of suitable technology is a barrier, however, most informants seem to agree that this is less of an issue now than just a few years ago. Cheaper and better devices, the emergence of connectivity technology like NB-IoT and similar protocols has been enablers of many of the projects in the empirical material, however, there is still potential for further improvement in the area.

5 Discussion

Municipalities rely on private actors and universities in a multitude of ways. This comes with a set of benefits for the municipality as well as the private party, but there is also a challenging part of the partnerships where barriers of digitalization and difficulties in collaborating are encountered (Ferraris et al., 2020). To understand the dynamics both in relation to the contribution of the private party and the barriers met when collaborating with them two research questions were asked. The two research questions will be discussed individually at first, before they are discussed collectively at the end of this chapter. The goal of the latter is to understand the possible responses to the barriers that have been identified in the light of the role that private actors as well as universities are playing in digitalization and innovation.

RQ1: How does digitalization and innovation happen in Public-Private Partnerships in Norwegian municipalities?

5.1 Four types of public-private partnerships

Through the interviews several types of IoT projects were identified. The characteristics of the projects varied across municipalities and firms. Two key dimensions were identified that the projects may be organised along. The first dimension is along an explorative and exploitative axis which, simply put, references whether a similar implementation has ever been done before in a similar context. Studying municipal innovations along a explorative-exploitative axis is very common in theory (Ferraris et al., 2018; March, 1991; Nielsen et al., 2019). The second dimension is related to whether the projects are managed by the municipality or the private actor.

Table 5.1 Four types of innovative municipal-private partnerships

	Exploitative	Explorative
Managed by Private company	**Type A – Exploitative by private** Outsourcing of implementation and management of an IoT project. **PPP3**	**Type B – Explorative by private** Projects initiated by a private party seeking to develop their solution in the municipality. The private firm has a long-term goal of selling the solution to many municipalities. **PPP4, PPP5**
Managed by municipality	**Type C – Exploitative by municipality.** A municipality purchases and implements an IoT solution. **PPP1**	**Type D – Explorative by municipality** Hardware and often a platform is provided by a private party, but finding use cases and managing the project is done internally in the municipality **PPP2**

In terms of who manages a project, projects often share the management responsibilities, however, one party usually has it to a higher degree than the other and making the final calls. Comparing this to Ferraris et al.'s (2018) typology which is summarized in Figure 2.3, I distinguish between four different types of partnerships, while they distinguish between two where the explorative alliances are manged by the private party and the exploitative has a shared management structure. This partly points to an increased willingness in municipalities to manage innovative IoT projects compared to the cases from Ferraris et al. (2018). The reason for this could be coincidental, however, it may also be linked to Norway doing quite well compared to other European countries in digitalization according to DESI (EC, 2019), which indicates a higher competence level and suitability for manging such projects. Considering that managerial capabilities is lacking in the public side of public-private partnerships (Scuotto et al., 2016), this is an uplifting finding.

Looking at the partnerships from an Open innovation perspective, and more specifically Gassmann & Enkel's (2007) open innovation archetypes we see several typical open innovation projects that fit in both the inside-out and outside-in archetypes. Taking the perspective of the private party the Type B cases can be classified as Outside-in innovation with the inflow not consisting of technology, but rather the internal practices of a municipality, tacit knowledge, user experiences and potential of the technology in the environment it operates in. The Type D case would be considered an inside-out strategy by the private party in that they offer their technology at a discounted price along with platform access to hopefully see a municipality scaling up a solution, or even better, developing something that has potential in other municipalities and contexts.

In addition to this, the Type B cases does support Chesbrough's (2010) claim that SMEs can benefit from doing open innovation. It also shows that these benefits are available through collaborating with public organisations in addition to private parties which supports the notion that the open innovation framework also suits public organisations (West & Bogers, 2017).

In terms of the benefits for the municipality associated with the different projects, they change along the dimensions. First, explorative projects mainly have a goal of experimenting and competence building instead of direct cost savings. This is in line with Ferraris et al. (2018). In the opposite end, the exploitative projects have cost savings, or other goals such as sustainability or improved citizen services as a main goal. These expected benefits transfers to the private parties as well, with the financial benefits of the exploitative projects being clearer than those that are explorative. In fact, for the private party, the explorative projects are considered an investment with little to no income generated. They do however expect significant return on the investment down the line, as the products are more refined, and economies of scale can better be put to use.

Apart from the more concrete benefits of cost savings, sustainability and improved citizen services, competence building and knowledge flows between the parties is an important benefit, often more important than the concrete benefits themselves. The goal of competence building for the municipality was especially prevalent in the Type C and Type B cases, with some elements of it in the Type A case as well. This confirms Santoro et al.s (2018) findings in that partaking in Open innovation increases the knowledge management capacity of a firm. While this research applies to the municipality, it is more than reasonable to presume that Santoro et al.s (2018) findings implies to public organisations as well.

An important prerequisite for competence building is that the municipality partakes in managing the project. In the Type B cases, where the private party managed the project, the municipality representatives were mostly bystanders in the project and through this role very little competence building occurred. Similarly, the Type A case, where the private party was also in charge, the case saw less competence building compared to the municipality-managed projects. However, in this case the management responsibilities were shared more compared to the Type B cases. What this indicates, is that for a municipality to build competence, they need to be involved in the projects in a managerial capacity and not only as passive participants.

Considering the management dimension of the matrix in Table 5.1, there is a clear trend that the more advanced the technology, the higher the demand is for technological capabilities, and thus the more likely the project is to be managed primarily by the private party. This indicates that another important contribution of the private party is related to two types of capabilities. First, management capabilities in managing these projects is needed. Secondly, and closely linked to the management capabilities is the technological capabilities. As shown by both theory and the findings, IoT technology is often very complex which exacerbates the need for such capabilities (Porter & Heppelmann, 2014).

In terms of these capabilities, an important distinction should be made between the capabilities available in the IT-division of a municipality compared to the service section such as the healthcare and water service sections. The ICT capabilities in the IT division is of a completely different character than what one may encounter in the e.g. the water service division. In this regard, an interesting characteristic of municipalities is that one rarely sees both ICT and domain specific competence and capabilities present in the same individuals. On the contrary, in private firms we do see this combination of ICT and domain specific competence which arguably is important to understand both the needs of a division as well as how they can be met by IoT technology. Thus, the combination of ICT competence and domain specific competence is a key contribution of private parties in these collaborations.

5.2 Ecosystem perspective

Considering the importance of ecosystems in relation to IoT technology, it is an area where the municipalities should rely on them for digitalization efforts. In none of the cases did the municipalities seem to have a keystone role in an ecosystem, but rather a niche role. However, many public-private initiatives were closely linked to a bigger ecosystem. In the Type B cases, the private firms were indirectly giving a municipality access to the technology and resources of an entire ecosystem as shown in Figure X. Similarly, the private partner from the Type D case also provided access to a larger ecosystem.

The role of the Welfare technology spin-off and Water Service Supplier are both a keystone in their respective small ecosystems. From there they manage the different suppliers which take on more of a niche role. For the private actors in these situations, it is essential that they consider the pains and gains of the ecosystem actors in line with Bullinger et al. (2017) and Iansiti & Levien (2004). Looking at the municipality in particular this is interesting, since with Type B projects they could experience significant disruptions to their operations as well as having to invest significant man-hours. Taking this into consideration, it may be so that the municipal party may be more inclined to pass on such projects and rather wait for a finished product to hit the market. In the cases studied here, the motivation of the municipality seemed to be a combination of good PR, pride, early access to products and a general wish to contribute to the digital transformation. In summary, the keystone actors in explorative projects needs to be extra wary of this perspective to ensure the sustainability of the projects.

In addition to this, forums where industry actors from within municipalities were deemed to be very important, indicating that this is also a key contribution of private firms. In some cases, these forums, or networks, were purely municipal, while others were for municipalities but by private actors. Interestingly, it seemed that those who included private parties were initiated and managed by the private parties. This could indicate that the capabilities of a municipality to manage ecosystems is lacking. Gassmann & Enkel (2007) discuss relational capability as important for coupled innovation processes, and it could be argued that similar capabilities may be central to innovation processes happening across ecosystem actors. Still, no conclusions can be made strictly on the empirical material here, but an important contribution of private parties is for municipalities to attain access to larger private ecosystems where they can get access to new technology and innovative ideas.

Open data was discussed with the municipalities, but only one municipality seemed to have a clear open data strategy, while another did see the value in data, but without having a clear strategy of collecting and opening it up to the public. Considering the potential for open data to drive innovation and business development in municipalities, the degree of open data strategies should be greater so that private actors can independently offer improved services for citizens (Abella et al., 2017; Moorby, 2020). From the empirical material, a key reasoning for why this doesn’t happen to a greater degree is concerns related to privacy since open data could inadvertently be identifying of individuals whether that is municipal employees or its citizens. Another reason for the lack of open data and data sharing from municipalities is because of data being difficult to access. This is clearly related to many digital solutions being proprietary and made without any open APIs and thus being locked down in “silos”, or its own verticals. The issue faced by municipalities wishing to open up data could explain the consensus that future solutions need to be built with open APIs, or the ability to “talk to other systems” as it is often referenced to. Thus, based on this, choosing open data and open IoT ecosystems in line with infrastructure similar to what is suggested by both Ahlers et al. (2019) and Robert et al. (2017) seems to be the way to go for municipalities and private firms working with municipalities.

5.3 Barriers for innovation and digitalization

There are numerous barriers identified in the empirical material which are of different character and size. With so many barriers identified, the possibilities of digitalization in Norwegian municipalities may seem bleak. Still, some perspective is needed. In particular, it should be mentioned that Norway is among the top countries in the area as shown by DESI (EC, 2019). In addition to this, there seems to be a solid willingness among municipal actors to digitalize indicating that the will is there and at least part of the means to do it. While the research question is to a large degree answered through the findings, the implications and potential responses to the barriers is relatively little discussed. The research question was as follows:

RQ2: What are the barriers for innovation and digitalization that is encountered in public-private partnerships and how can they be mitigated?

Below follows a comparison of the barriers with earlier research and statistics as well as a discussion of the responses by the municipalities. In addition to this, where applicable theory on how to overcome the barriers, this will also be discussed.

Parallel to this paper Ferraris et al. (2020) was published with a very similar research question and theme where they investigated the barriers experienced in the municipality for implementing open innovation in smart city projects. Open innovation practices are thoroughly investigated in this paper and therefore that is a shared feature of the research projects. Beyond this the papers differ in that this paper investigates smart municipalities rather than smart cities. Furthermore, it investigates what is considered small to medium-sized municipalities in a European context, while Ferraris et al. (2020) investigates large municipalities. Lastly, this paper has also identified some technical and contextual barriers that falls outside of the scope of Ferraris et al.'s (2020) paper. All over, this paper has a lot in common with Ferraris et al. (2020), but does differ in context and has a wider scope.

Considering the similarities of the papers, some common findings is expected to be found. In Table 5.2, the barriers identified by Ferraris et al. (2020) are outlined and whether this paper confirms the findings.

Table 5.2 The barriers for open innovation in municipalities compared to the barriers identified in this paper.

Ferraris et. Al. (2020)	Findings
Lack of rules, tasks and responsibility	This is to a certain degree confirmed. Many municipalities in the empirical material lacks anchoring of IoT projects in higher levels and projects are often championed by people without them actually being given the tasks and responsibilities.
Insufficiently integrated view of the city planning	This barrier was not found in the empirical material. This could be attributed to the differing contexts where doing city planning is far more complex in large cities compared to small and medium-sized municipalities.
Lack of fit of administrative styles and inter-departmental coordination and communication	This is confirmed. The administrative styles is often very different in municipalities and private firms which may lead to tension and issues. Furthermore, many projects are not coordinated with other parts of the municipalities which limits the opportunities for some solutions to have a wider impact beyond only one municipal division.
Risk-aversion	This is confirmed. In the empirical material this is closely linked to disincentives where it is better to keep the status quo rather than risk a large failed project.
Dis-incentives and non-flexible procurement rules	This is confirmed. Both in relation to risk-aversion as mentioned above as well is non-flexible procurement rules. The issue of procurement rules is to a certain extent mitigated by some flexibility in small project (Under 100k NOK).
Lack of resources	This is confirmed. Lack of resources is an issue, although it does vary with municipalities, and in some cases the private

	actor does see it as useful to fund the entirety of the project.
Lack of technological capabilities	This is confirmed. The lack of technological capabilities is a large issue, both in the different municipal divisions and even in some cases the IT division.

All over, the findings confirm the results of Ferraris et al. (2020). While this does aid in strengthening the findings of Ferraris et al. (2020) it also does show that they are to a large degree transferrable to small to medium-sized Norwegian municipalities as well as contexts outside of the smart city. Considering the importance of the context in which smart solutions are implemented (Hosseini et al., 2018), seeing that there are common characteristics in what can be regarded as very different projects points to that smart city research may be relevant in very different fields than just smart cities themselves.

Considering the barriers for digitalization mentioned by SSB (SSB, 2020), one contradicting finding is rules regarding public procurement processes. Only 19.1% of municipalities report this as a barrier for digitalization, however, it seemed to be much more common in the empirical material. There are several possible explanations to this. First, the data material is different, with this review including four private actors and one from academia. Therefore, one possibly explanation is that the barrier related to public procurement rules is mostly experienced by private parties rather than the municipal parties that the SSB statistics are based on. A second explanation is that the IoT projects differ from other digitalization projects in the municipality where IoT projects is often more negatively affected by procurement rules. Lastly, it could also be coincidental and with a wider set of informants, problems with public procurement rules may reveal to be as small as it is in the SSB statistics.

5.4 Responding to the barriers

5.4.1 Building competence

The lack of competence was the most reoccurring theme in the interviews, which is in part because of explicit questions were asked about it in the interviews, but also because this is an issue in Norwegian municipalities with nearly half of municipalities citing this as an issue according to SSB. Furthermore, with municipalities doing ICT projects with internal resources the issue is even bigger (Rybalka et al., 2019).

Increasing the competence level in a municipality does not seem to be an easy task. Ferraris et al. (2020) suggest both more training of human resources in public organizations as well as hiring skilled human resources. The source of skilled human resources is often universities where newly educated young people may provide municipalities with innovativeness. However, hiring people with the right competence is an issue in Norwegian municipalities, with 50% of those who has attempted to recruit ICT-specialists are struggling (Rybalka et al., 2019). This indicate that for municipalities, simply recruiting the competence that is needed is not necessarily a quick fix for these issues. A reasoning for this lack of competence could be related to weak incentives in the public sector which Kvaløy & Mohn (2018) argues could lead to the most competent young professionals going to the private sector rather than the public sector.

In building competence, the university plays a key role in several different ways. In relation to recruiting, it is as already stated an important source of young skilled labor. In accomplishing recruitment from universities, one municipality saw great value in doing guest lectures and having close ties to universities and colleges. However, the universities can provide competence more directly than through recruiting. In both university partnerships in the empirical material, the university was acting as knowledge providers (Ardito et al., 2019). This was especially prevalent in the waste management case where the municipal representative benefitted significantly from the increased understanding of optimization models. This understanding could be used when dealing with solutions from private parties in the future which shows how the university, although indirectly, can aid a municipality in collaborating with private parties.

In terms of university collaboration, there are a few difficulties that could occur. In part is the strong focus universities has on publishing. Considering that a key role of the university is to provide scientific findings for society as a whole (Etzkowitz & Leydesdorff, 2000), this is an important part of their work, but for private and municipal parties who wants to see immediate benefits, it may be a lengthier process than they would normally prefer. There is also the issue that the competence derived from research in universities isn't directly transferrable to a municipal context. One informant stated that an important activity in the knowledge transfer from universities to municipalities is a form of "translation" from the academical to the more practical knowledge needed in a municipality. Thus, university collaboration doesn't come without needs for compromise and adaptation where the work processes and

Santoro et al. (2018) findings that open innovation leads to an increased knowledge management capacity is to a large degree supported, since we see that many of the municipalities partaking in such initiatives learned significantly from this. However, while Santoro does find several correlations between the different elements in their research, the direction of the effect is assumed, but not argued for. While this research is not extensive enough to contradict the findings to a large degree, a possible interpretation of the results in this paper is that knowledge management capacity may also affect whether an organization partakes in open innovation. In one of the Type B cases, the lack of competence and technical capabilities led to the municipal parties having an increasingly passive role in the project. Thus, it may as well be knowledge management capacity having a positive influence on the open innovation activities in a firm than the other way around, or possibly a combination of the two. Still, based on Santoro et. Al. partaking in such open innovation projects seems to a large degree to be competence building for the municipality and thus should be encouraged.

5.4.2 Public procurement rules

As stated before, the barrier of public procurement rules is two-fold. One is related to a lengthy process of doing procurement above 100k NOK, while the other is related to municipalities having framework agreements with a certain vendor, which prevents them from choosing another, superior vendor for even the smallest of IoT solutions. The workarounds or responses to these challenges varies greatly.

When it comes to the little flexible rules regarding tenders, the response of several partnerships is to only make deals for small projects where the total cost for the municipality is below 100k NOK. This is solution that only allows for small scale solutions, often pre-projects before a larger municipality-wide solution can be implemented, which makes this solution far from suitable if the goal is to tap into the large potential in digitalization (Mellbye & Gierløff, 2018). Furthermore, these projects are often referenced as small pre-projects to test a solution or a technology. However, considering the path-dependency that often goes along with IoT solutions (Lo et al., 2019), this could lock in a municipality with the vendor of the pre-project. This has two consequences. First, it may end up creating issues for the municipality, in that they can't or will struggle to choose a more optimal solution when it is presented after the pre-project. This is made even more significant if the system from the pre-project is not made with open non-proprietary solutions (Ahlers et al., 2019; Hosseini et al., 2018; Robert et al., 2017). Second, it may pave the way for cunning private actors in doing relatively cheap pre-projects with municipalities with the goal of locking them in to their own solution. While no direct evidence has been found of such practices among private actors, it is certainly a risk that municipalities should be aware of in these partnerships.

Secondly, when it comes to being locked in with less than ideal framework agreements, there are two ways municipalities can deal with this. First, working to get more competence in the municipality is important so that municipalities can avoid binding themselves to these agreements is important. Further suggestions on this is in section 5.4.1. In addition to this, working to have more flexible agreements is key. In nursing homes, what seems to be a common practice, is that one vendor is responsible for all IoT and welfare solutions through a framework agreement. Having an opening for different solutions for other vendors in the framework agreements when they are significantly cheaper or better is a potential solution. Still, this requires a certain purchasing power in the municipality to negotiate this.

5.4.3 Lack of trust

The lack of trust between the municipal and private party takes on two forms. First of all, the private party is wary of sharing information with the municipality. A solution by one informant is to actively use NDAs with all parties involved with the technology which is in line with the strategy of IBM managers when working with public actors in smart city projects (Scuotto et al., 2016). The second way it manifests is the municipalities lack of trust towards private actors, primarily because of skepticism related to whether a presented product is the best and most suitable. In short, it may be summarized as an issue related to information asymmetry. Similarly, to the issue of framework agreements this is also rooted in a lack of competence in the municipality. Therefore, the initiatives mentioned above to increase competence will to a certain degree help this issue as well.

For the municipality, an increased use of consultants is also a possible solution to this issue. First of all, consultant companies have a significant level of competence (Etzkowitz & Leydesdorff, 2000), which may aid the municipality in filling in the competence holes and thus indirectly remedy the issue of trust towards private actors.

Furthermore, the consultant company has a much wider range of products they can chose to offer a municipality than a traditional IoT vendor in that a traditional vendor will only have their own products to offer, while the consultant company can choose freely in the market. The consultant company interviewed stated that this was their strategy and that they would choose whichever products was best for the municipality. Thus, relying on consultant companies to make some of these decisions could be beneficial for a municipality, especially where the competence level is low.

5.4.4 Organisational issues

There are many elements to the organizational issues related to cultural issues, risk-aversity, disincentives and lack of anchoring. Looking at incentives in the public sector, (Kvaløy & Mohn, 2018) argues that they are not suited for productivity growth. This is also suggested by these results, both in that there are little incentives to increase productivity, but also that choosing a risk-averse route is often recommended out of political considerations. Parts of this relates to the incentives themselves, while other relates to cultural issues, such as the municipality being conservative or simply being more risk-averse than the private sectors counterpart (Kvaløy & Mohn, 2018). Similarly, to the competence issue, this may also be mitigated by recruiting the right people, however, it does require that incentives are structured in a way that attracts young, risk-seeking and innovative people (Ferraris et al., 2020).

Beyond this, the municipality could possibly benefit from theory on the ambidextrous organization (Raisch & Birkinshaw, 2008)ra. Through separating some of the innovative efforts and responsibilities to specific people or divisions, the municipality may be able to disentangle from the conservative and risk-averse culture of the municipalities.

Some municipalities do have a municipal digitalization manager responsible for digitalization efforts. This type of organization was not present in any municipalities in the cases, but both private and municipal partners saw the need for a more holistic strategy and effort for the municipality and better anchoring at higher levels of the municipality which indicate that this may be a model worthy of following for many municipalities.

5.4.5 Platforms and open data

Data being locked down in different verticals is a well-known issue from theory (Hosseini et al., 2018) and it is no different in the empirical material. However, the fact that both private and municipal actors are nearly unanimously in agreement that open ecosystems is the way to go it could indicate that we are heading the right way. Municipal and private actors do need to be vigilant in working towards increasingly open ecosystems, especially considering the profitability of locking in a customer in closed ecosystems (Porter & Heppelmann, 2014)

For municipalities to have a say in how platforms are managed they should have a certain size and financial power so that they can force the private platform owner into opening up their platform(Gawer & Cusumano, 2014; Helfat & Raubitschek, 2018). In the empirical material, the purchasing power of a municipality was considered central in making private actors offer open solutions.

Also, increasingly offering open data, like the project in Denmark is an area of promise. Considering that only one municipality had an active strategy on this, it is certainly an area for improvement. The late development of open data repositories seemed to relate to privacy issues which is not easily overcome.

5.4.6 Costs and technological difficulties

Lastly, contextual issues, mainly related to the costs of IoT is an issue. Whether this problem is related to lack of funding or simply IoT being too expensive is in many ways semantical. Either way, attacking this issue is in part done by waiting for better and cheaper solutions to come around, but considering the Type B projects, a way of accelerating this growth is by partaking in explorative projects. The municipality has the immediate effect of getting a cheap small-scale solution and the long-term effect of seeing better solutions being developed. The latter benefit can and should also be considered from a perspective where the total social return on initial investments is done since the benefits of such projects benefits far more than just the municipality participating in a prototype project in the long term.

5.5 Future research

Considering the cross-sectional nature of this study, following innovative IoT projects over time would be beneficial to further explore the dynamics between private parties and the municipality. Considering Nielsen et al.'s (2019) findings that what is meant to be explorative municipal projects tend to become exploitative as the municipality moves forward with a project may also apply to the project in this review. Seeing whether this is relevant to innovative IoT projects is worth finding out. Furthermore, following a project over time and seeing how, or if, it develops from an explorative approach to an exploitative approach could unfold what the long-term benefits of such projects really are.

Another area relevant for future research is related to the issue of public tender processes which in this review was considered a more significant barrier than it was perceived like in the municipalities in SSB's (2020) examination. More research on how this may obstruct innovative digitalization projects could provide interesting findings on how the dynamics between public and private partners in innovative projects are affected by public procurement rules.

6 Conclusion

This thesis has identified four types of public-private partnerships in Norwegian municipalities working on implementation or development of IoT solutions. The four types are categorized along two dimensions, explorative-exploitative and whether it’s managed by the municipality or the private party. Comparing it to previous similar research it could be regarded as an expanded version of Ferraris et al.'s (2018) twofold classification of public-private partnerships in smart cities along the explorative-exploitative dimension. This shows that municipal innovative IoT projects is very diverse in terms of characteristics, goals and motivation of both the private and public party

The different projects characteristics vary between the different dimensions. First of all, competence building in the municipality is much stronger in the projects managed by the municipality. In light of the lack of competence in municipalities that has been confirmed in this review, this is especially interesting (Chang et al., 2020; SSB, 2020). Furthermore, financing in explorative projects is done to a large degree by the private party, while exploitative projects are usually financed entirely by the municipality. This is linked to the goals of the projects, which in the exploitative projects is usually concrete benefits (e.g. cost savings), while in the explorative they concrete benefits are usually not expected for some time and PR, pride of being in an innovative project and competence building being the more immediate benefits.

Looking beyond the inter-dynamics of the public-private partnerships, municipalities use private parties to be able to access and tap into the resources of a larger ecosystem. Municipalities in general had a niche role, rather than a keystone role which in most cases seems to be the private parties they are collaborating with.

In addition to examining the characteristics of innovative IoT projects in Norwegian municipalities, this review has uncovered barriers encountered in these public-private partnerships. A multitude of barriers and difficulties in relationships has been found of varying sizes. Three main categories have been found based on where the problems arise from and how they materialize. Collaborative barriers include public procurement rules and municipal processes and a lack of trust. The former barrier could indicate that a revision of the framework could be suitable and that municipal procurement officials should be wary of overly extensive framework agreements since they could inhibit innovation in the municipality. The latter barrier which is lack of trust is rooted in a lack of competence in the municipality and underlines the importance of competence building in the municipality.

Lack of competence is the first of three organisational barriers. Lack of competence mainly relates to ICT competence and awareness of the possibilities in IoT. Building up this competence can be done in a multitude of ways, from taking part in managing digitalization projects, to recruiting actively from universities as well as including them as knowledge providers in IoT projects. In addition to competence issues, cultural issues related to a conservatism in the municipality along with a general risk-aversity was found. A likely explanation to this was related to incentives in the public sector (Kvaløy & Mohn, 2018). Lastly, better anchoring with leadership in the municipality is needed. Having dedicated personnel with an oversight of digitalization project is an approach chosen by some municipalities and could be very relevant in many of the municipalities that has been looked at.

The third category is contextual barriers which consists of problems in the ecosystems and lack of resources. Problems in the ecosystem mainly relates to a lack of standards and each provider having proprietary solutions. For municipalities to avoid having their digital solutions locked in verticals, they must user their buyer power to force private suppliers to open up. This is however difficult for small municipalities.

6.1 Future research

Considering the cross-sectional nature of this study, following innovative IoT projects over time would be beneficial to further explore the dynamics between private parties and the municipality. Considering Nielsen et al.'s (2019) findings that what is meant to be explorative municipal projects tend to become exploitative as the municipality moves forward with a project may also apply to the project in this review. Seeing whether this is relevant to innovative IoT projects is worth finding out. Furthermore, following a project over time and seeing how, or if, it develops from an explorative approach to an exploitative approach could unfold what the long-term benefits of such projects really are.

Another area relevant for future research is related to the issue of public tender processes which in this review was considered a more significant barrier than it was perceived like in the municipalities in SSB's (2020) examination. More research on how this may obstruct innovative digitalization projects could provide interesting findings on how the dynamics between public and private partners in innovative projects are affected by public procurement rules.

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Appendix

Appendix 1 - Interview guides

Interview guide for municipalities

1 - Background and introuction

What is your role in the municipality?

How many employees does the municipality have?

What is the status on digitalization and use of IoT in the municipality today?

What are the differences between different sectors such as water and wastewater, health, education etc.?

Do you have your own network for development and experimentation? E.g. LORAWAN?

How are digitalization and IoT-initiatives organised in the municipality

What third parties are involved in the development of these solutions?

What are the goal of doing digitalization? What are the benefits?

2 – Collaboration with private actors

To what degree are you involved in innovative projects? Do you take part in the development of new technology?

Do you actively share any data with private actors or academia?

Do you often open up for private firms to test their solutions in your operations?

Are you doing any IoT-related projects right now?

How would you describe the partnership with private actors related to IoT? Are you passive customers or actively co-creating?

Do you notice large differences in how it is to collaborate with different actors? What leads to these differences?

Have you experienced any challenges in collaborating with these actors?

Based on your experience with private actors, how would you change your way of working?

How are the financing done in the private IoT related projects?

3 – Collaboration with universities

Have you conducted any projects with universities? What types of projects are this?

What do you contribute with? What does the university contribute with?

Do you see any drawbacks or challenges when collaoborating with universities?

Why do you collaborate with universities?

Has it given you any benefits?

5 – Closing remarks

What types of problems do you think the municipality can solve through digitalization and IoT?

What barriers do you see in relation to digitalization and IoT in the municipality?

Interview guide for private actors

1 – Background and introuction

What does your firm do today? What is your core value offering?

How large are the shares to the public and private sector?

What is your role in the company?

How many employees do you have?

How is the development of IoT organised in your firm? Do you have any third parties involved? Which third parties?

What type of connectivity do you use for you IoT solutions?

2 – Municipalities – Collaboration and innovation

How is to develop IoT solutions with municipalities compared to private actors?

Do you have any form of collaboration with municipalities today? How are the collaborations managed?

How is the financing done in these projects? Who is taking on the risk?

Who is your contact person in the municipality?

Is the municipality involved in the work that you do? Do they contribute actively with advice?

Is there something that you would like the municipality to contribute with that they are not contributing with today?

What is the competence level in the municipality when it comes to IoT and digitalization?

In case of a pilot project – Do you think the municipality will be a customer of you in the future?

Do you think the municipality is learning something from you?

Has the process of working with the municipality led to any adjustments to your business model?

3 – Academia

Has there been any universities involved in your projects? What has been the universities contribution?

Do you see any advantages or disadvantages of collaborint with universities?

4 – Digitalization and IoT

What barriers do you see for the municipality to increase its usage of IoT and digital solutions?

Does these barriers apply to your product offering?

What type of issues can the municipality solve through digitalization and IoT?

Interview guide for academia

1 - Background and introduction

What is your role in the academic institution?

How does your job relate to smart cities and digitalization in municipalities?

2 - Academias role in smart city and digitalization in municipalities

Is the university deeply involved, or are you more of a peripheral actor?

Concretely what is it that the university is contributing with towards smart cities and digitalization in municipalities?

What are the most important contributions of the academic institution in such projects?

Why are universities important to include in such projects?

Do you see any drawbacks for municipalities of including universities?

What is the motivation of the academic insitution to take part in such projects?

3 – The municipality

What type of obstacles do you see for municipalities to increase their usage of IoT and digital solutions?

What type of problems do you think a municipality can solve through digitalization and IoT?

NTNU

Norwegian University of
Science and Technology