Smart City Development in Nordic Medium-sized Municipalities

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Abstract

The Nordic countries stand out as digital frontrunners in Europe as well as in a global perspective. However, smart city development in medium-sized municipalities in the Nordic region is less researched than large Nordic cities. Hence, the purpose of this paper is to study how medium- sized municipalities in the Nordic region are organized for smart city development, and how the development is influenced by contextual factors. Data has been collected through interviews of smart city and digitalization leaders in medium-sized municipalities in Denmark, Finland, Norway and Sweden, as well as secondary data in the form of strategy documents, statistics and reports. The analytical approach is multiple case study analysis where the selected case-municipalities are analyzed and compared in terms of understanding of the smart city concept, smart city governance, resources and collaboration. Our findings indicate that there are great variations in the maturity of smart city development in medium-sized municipalities in the Nordic region. The findings indicate that successful implementation of smart city projects is related to a structured organizational setup, clear goals and strategies, support from a strategic facilitator and focus on project scaling. Further, the findings suggest that the contextual factors local autonomy, local conditions and the country-level approach to public innovation influence smart

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city development. The paper provides originality and value by identifying characteristics on how smart city development is organized in medium-sized municipalities across Nordic countries, and how the development is influenced by contextual factors.

Keywords: Smart city development, Smart city governance, Contextual factors, Municipality, Nordic Region.

1 Introduction

The Nordic countries, Denmark, Finland, Norway and Sweden stand out as digital frontrunners in Europe, and are in the top-tier of many digitalization indexes [1, 2, 3]. Several factors indicate that the Nordic countries have great potential for integrating smart technologies both to create value for citizens and in a commercial context. Smart technologies refers to technologies used to generate value from data and includes amongst other; internet of things, 5G and cloud computing [4]. In terms of progress towards a digital economy and society, the Nordic countries are above the EU average when it comes to mobile and fixed network deployment, degree of human capital (ICT experts and internet user skills), online activities and transactions, integration of digital technology and use of digital public services [1]. Additionally, the Nordic countries have a strong position when it comes to 5G readiness. The countries are considered to have the infrastructure and technology, the regulation and policies, innovative landscape and human capital needed for adaption of 5G technology [2].

Further, large cities in the Nordic countries are often represented in the top-tier of smart city rankings. All the Nordic capitals are amongst the top 50 smartest cities in the world [5, 6]. In addition to the capitals, several large Nordic cities have been represented in the top rankings of European smart cities [7, 8]. Hence, Nordic cities stand out as able to integrate smart technologies in public services. A recent comparison of 60 municipalities across the Nordic countries shows that the Norwegian municipalities score highest on digital services and smart cities [9]. There large municipalities score higher than the small and medium-sized ones.

However, the Nordic countries are also characterized with more scattered settlements, and smaller cities compared to the rest of Europe. 75% of

Nordic residents live in urban settlements [1] with more than 2.000 inhabitants. However, only 45% lives in urban areas with more than 50.000 inhabitants[2] [10]. Hence, small and medium-sized communities and cities have a strong position and are prioritized in regional development in the Nordic countries. The Nordic countries do experience depopulation in rural areas, but small and medium-sized municipalities have the potential to remain attractive places to live through development programs and municipal service improvement. Digitalizing to create better and more seamless services might prove an important step for small and medium-sized municipalities to increase their attractiveness [10].

Even though the Nordic countries stand out as digital frontrunners at a country level, few studies have examined the smart city development in medium-sized municipalities in the Nordic countries. Existing research on smart city development in the Nordic countries includes a framework to evaluate and adjust smart city metrics to arctic and remote locations [11], and an article on governance structures of smart city initiatives in three medium to large sized cities in Norway [12]. However, research within the area remains scattered, and there are no studies to our knowledge, which comprehensively study smart city development in medium-sized Nordic municipalities.

In order to fill this gap of research, we perform a multiple case study analysis of one Norwegian, Swedish, Finnish and Danish municipality and proposes the following research question:

How is smart city development organized in medium-sized municipalities in the Nordic region?

The research question aims to create an understanding of the state of smart city development in the selected Nordic municipalities. It is further interesting to discuss how contextual factors such as local autonomy and local conditions affect smart city development. Additionally, there are significant differences in how the countries govern digitalization efforts on a national level [13] which might also have influencing effects.

In order to perform the multiple case study analysis, we use a framework consisting of four dimensions with related sub-dimensions. The dimensions are the understanding of the smart city concept, smart city governance, smart

[1] In the Nordic region an urban settlement is considered to be 200 people living within 200 meters (in Norway 50 meters).

[2] An urban area/centre have a population size above 50.000 inhabitants (min. 1.500 inhabitants/km^2) according to OECD

city resources and smart city collaboration. The framework was created to be able to organize and compare the empirical data from the four cases, and was established by considering the applicability of existing theoretical frameworks to the empirical data.

The rest of this paper is structured as follows; in Section 2 relevant research regarding smart city development is described, next the Nordic context is described in Section 3 to understand the country-level dynamics which might have an effect on smart city development. Further Section 4 presents the methodology which includes the case selection criteria, a description of the data and how it has been collected, and a presentation of the analytical framework used to analyze the data. Moreover, short descriptions of each of the cases are given in Section 4. The main part of the article is Section 5 which presents the findings from the case-municipalities in a systematic way. Last, Section 6 discuss the findings of the analysis and points out limitations and areas of further research.

2 Theoretical Background

This section presents the relevant theory related to digitalization and smart city development in medium-sized municipalities. The two concepts are strongly related, however, they are not strictly defined terms, thus, they can be understood and analyzed from multiple perspectives. First, the smart city concept is placed in the context of the advancements of an e-government to a smart government, conceptualized in the e-government stage model [14, 15]. Further, the relation between a smart government and a smart city is explained [16], and the smart city concept is elaborated [17, 18, 19]. Next, applicability of the smart city concept is discussed in relation to municipal size and territorial and demographic factors [7, 11, 20–24]. Lastly, relevant theory related to the governing of smart city development is presented [12, 25, 26] and the related smart city ecosystem [27–30].

From e-government to smart government and smart cities

The e-government concept describes how information and communication technologies (ICT) are being used to support public duties efficiently and effectively [31]. Further, the e-government stage model describes the level of which a government has been able to use information and communication technologies to integrate and improve their services [14]. The stages includes publishing information, interaction and transaction, vertical integration and horizontal integration sharing information with other agencies [14].

The first step, publishing information, is the most basic form of e-government and describes to what extent the municipality provides information to its citizens online. Interaction and transaction takes it one step further and includes digital user interaction with citizens, in example online registration or payment of services [20]. Taking the step from a transactional e-government to the integrated stages (stage three and four), requires organizational change. The third stage includes linking local systems to higher level systems within similar functionalities [14]. In the fourth stage, horizontal integration, systems are integrated across different functions which enables information obtained by one agency to propagate through all government functions [14]. The fourth stage also includes open government data, digital complaint management, collaborative project systems and electronic consultation of public stakeholders [31]. The stage model has later been expanded to include a fifth stage focusing on the transition from an e-government to a smart government. Governments in this fifth stage are data driven and able to proactively use and deliver information to citizens. Services of smart governments are designed to support automation and intelligent processing of available information [4]. A smart government uses Big Data Management, the Internet of Things (IoT), sensor networks, smart devices, embedded systems, 5G and cloud computing technologies in public administration to create entirely new ways of governing cities, states or nations [4].

The smart government concept is also strongly related to smart cities, and some scholars view smart city as a subset of the broader concept smart government. A smart government is able to do smart city development, where smart city is an area for collaboration and service co-production testing [16].

The ambition of a smart city is to increase the competitiveness of local communities through innovation, and at the same time increase quality of life for its citizens through better public services and a cleaner environment [18]. Smart city initiatives can be classified according to six dimensions, namely quality of life (Smart Living), competitiveness (Smart Economy), social human capital (Smart People), public and social services and citizen participation (Smart Governance), transport and communication infrastructure (Smart Mobility), and natural resources (Smart Environment) [7]. It can also be viewed as a five level pyramid [19]. The foundation of the pyramid are the basic requirements that have to be present in order to create a smart city, namely the physical areas of the city (e.g. buildings, parks and public spaces) and and the infrastructure (e.g. network deployment, transit roads, energy and water) needed to make the city smart. The top three levels includes collaborative ecosystems, applications (e.g e-government) and living. Further, smart

city strategies can be viewed as either “hard” or “soft”. The “hard” smart city strategies focuses on infrastructure and technology, while the “soft” strategies focuses on developing human and social capital [32]. Hence, the scope of smart city development is broad and can be implemented to improve a multitude of different municipal services.

Smart city development and size

The requirements of vertical and horizontal integration, as well as the adoption of smart technologies to create smarter municipal services put larger requirements on the municipality. Both the number of inhabitants in the municipality and the degree of urbanization might impact smart city development in the municipality. Characteristics such as population size, management support, networks of peer institutions and resident demands have an effect on the benefit of e-government adoption [20]. Furthermore, there is an ongoing discussion within the smart city research on the applicability of the smart city concept to smaller communities.

According to Hosseini et al. [21], small and medium-sized municipalities are not equipped with the same wide availability of infrastructure services as larger cities. Additionally, they do not have the same opportunities for economies of scale, nor the same range of opportunities for ecosystem collaboration with multiple actors. Many small and medium-sized municipalities also follow a ”one-size-fits-all” technological approach which often fail because it does not match the property of the municipality [21]. However, the authors also argue that smaller communities are potentially able to move faster than large communities with innovative efforts due to less complex infrastructure and network of actors [21]. In example, broadband connectivity and external partnerships, especially with adjacent communities, are important success factors for smart city development in rural areas [22], and smart city development can be used as a means to attract new industry as well as young professionals in order to counteract depopulation [22].

Furthermore, small, medium and large municipalities might have different views on the smart city concept. According to Desdemoustier et al. [23]the smart city concept can be viewed from a technological, societal, comprehensive or non-existent perspective. They found that small and rural municipalities often has no understanding or a technological view of the smart city concept, whereas medium and large municipalities more often develop a societal or comprehensive perspective. A municipality with a technological view of smart city development view a well-functioning

infrastructure, as well as technology, as the most important aspects to become a smart city. In contrast, a purely human-centred view focuses on human capital and education. A municipality with a combination of the two understandings are categorized as integrative [23].

The smart city characteristics of the municipality might also be affected by the population size of the municipality. Borsekova et al. [2018] analyzes the functionality between the size of a city and smart city indicators. It compares large cities (100.000–500.000 inhabitants) with mega-cities (300.000–1 million inhabitants). The study uses a quantitative approach to identify the most important predictors of city size among 28 smart city indicators. The results indicate that compared to mega-cities, large cities tend to be more ecological aware, innovative and open minded. Even though [24] analyze larger cities than the cases presented in this article, their results indicate that population size do influence the priorities of smart city development.

Grønning et al. [11] argue that the standardized smart city framework lacks focus on sustainability, and needs to be adjusted in order to be applicable for arctic cities. The aim of the framework is to be able to evaluate smart cities with low populations, peripheral development, remote locations and harsh climate conditions. According to [11], smart arctic cities require an enhanced focus on sustainability in order to meet the challenges of climate change. The study is based on three arctic cities with a population from 50.000–300.000 people. General findings from [11] is that a clear comprehensive strategy and external investments by businesses and foundations are important factors for smart city development in the arctic cities.

Governing smart city development

Governing smart city development requires that decision-making processes, control of development initiatives and project priorities involve all stakeholders so they build commitment and owner- ship of the final planning outcomes. In this context, the public authority plays the role of founder and regulator by bringing the interests of the different stakeholders together [12]. With the public authority as a facilitator of smart city development in mind, [15] identifies important dimensions of smart city governance; leadership, strategy, teams, management processes and principles, and performance measurement. They further argue that smart city initiatives cannot be run effectively without smart city leadership and a comprehensive strategic plan.

Ooms et al. [26] further elaborate on the interaction between smart city developments and in- novation ecosystems, and states that smart cities resembles innovation ecosystems. An innovation ecosystem is a system

of innovation networks where government, universities, industry, and non-governmental organizations participate to innovate new products and services [27]. In a smart city context, the rationale of the innovation ecosystem is to find new solutions to specific problems in the city by initiating, importing, modifying and diffusing smart technologies [33]. Further, the superior goal is to increase quality of life of the citizens in a sustainable manner [26]. A related term to an innovation ecosystem is the quadruple helix model. The model describes how public authorities, academic institutions, firms and citizens interact in order to produce products and services relevant for the citizens [27].

Each actor having a defined role in the system characterizes the interaction among the actors, however the inter-relations among the different actors varies. Academic institutions re- search to generate new knowledge, and can be viewed as knowledge intermediaries, knowledge gatekeepers, knowledge providers and knowledge evaluators [29]. Firms produce innovation in the form of new organizational structures, as well as products and services in the market [30]. Additionally, the public authorities might collaborate with private firms in public-private innovation partnerships for service development, or private funding can be given for service and infrastructure development [15]. Moreover, the role of the public authorities is to create new policies and support the technological development [30]. Lastly, the citizens play a pivotal role in smart city development, both because "they are the main addresser of smart initiatives, and because their involvement and participation is often required for the complete success of a smart project" (p. 2978) [33].

Smart city development is also affected by both formal and informal relations and processes. Gohari et al. [12] have studied how governance in the form of roles and power in smart city initiatives has caused governance to emerge, change, and affect the goals designed by specific actors. According to their findings, the smart city projects were influenced by the informal interactions of outside actors. The actors involved in the smart city development used their interpersonal connections to integrate their expertise or influence the definition of the problem. Furthermore, Ooms et al. [26] have analyzed the importance of the different governance factors in the different phases of the evolution of a smart city ecosystem. They found that governance factors such as a common goal and a joint overall strategy and internal cooperation strategy have an effect on the ecosystem effectiveness in the initiation phase. In the growth face, where the ecosystem expands, the focus in the ecosystem is that of establishing external relations with other parties, such as competitors and suppliers [26].

A challenge to smart city development is that the vision of the concept varies among the different actors in terms of technological, human and institutional factors. Universities often consider smart city "like an innovative place where to implement their pilots and experimental solutions". However, it is also found that universities "tend to neglect the digital divide, the difficulties in funding innovative facilities and the lack of competences in municipalities" (p. 2978) [33]. Moreover, private companies might enforce their own solutions on the municipalities without considering the needs of the citizens. The municipalities on the other hand, struggles with strategic planning and change management for smart city development [33]. In order to overcome this challenge, Angelidou [32] suggest that municipal governments and authorities operating at the lowest tiers of government start by selecting a few domains or areas needed to be improved urgently.

3 The Nordic Context

In order to understand the dynamics of smart city development in the Nordic countries, the governance structure and superior digitalization strategies of the different countries needs to be clarified. This section, will first present how the Nordic countries place in European digitalization bench-marks. Next, urbanization, national and regional influences, local autonomy and the approach to public innovation in the Nordic countries are discussed.

Digital benchmarks

This section presents three indexes benchmarking the digital performance of the Nordic countries. The E-Government Development index (EGDI) has been included as it measures the trends in e-Government worldwide [3]. The Digital Economy and Society Index (DESI) has been included because it summarizes relevant indicators on Europe's digital performance and track the evolution of the competitiveness of EU member states [1]. Further, the 5G readiness has been included because measures the readiness of European countries to adapt 5G technologies [2]. This index is of particular interest for smart city development as 5G is an enabler for future implementation of smart technologies in smart city development [34].

Table 1 gives an overview of the scores of the Nordic countries in three selected indexes. The EDGI index has a range of 0 to 1, the range of the DESI index and 5G readiness index is 0 to 100. All indexes uses min-max normalization. Further description of the methodology of the indexes can be found in [3, 35, 36].

Table 1 EDGI, DESI and 5G readiness indexes

Index	Norway	Finland	Denmark	Sweden	EU average	Indicies
EDGI total	0.8557	0.8815	0.915	0.8882	0.7240	Online service index, telecommunication and infrastructure index, human capital index
DESI total	66	69,9	68,8	69,5	52,5	Connectivity, Human capital, use of internet, integration of digital technology, Digital Public Services
DESI Connectivity	66,1	66,1	73,6	70,4	59,3	Fixed broadband, mobile broadband, fast and ultrafast broadband prices
DESI Digital Public Services	78	79,9	77,8	77,7	62,9	e-Government and e-health
inCITIES: 5G readiness total	64,08	70,95	65,93	65,91	53.03*	Infrastructure and Technology, Regulation and Policy, Innovation landscape, Country Profile, Demand
inCITIES: 5G readiness infrastructure and technology	62.53	67.44	51.18	56.58	49.19*	4G coverage, fiber coverage, internet bw per user, 5G commercial networks, # of IXP, # and maturity of 5G pilots, time to get electricity, 4G launch year, 5G spectrum auction plans
inCITIES: 5G readiness innovative landscape	56.21	64.24	65.52	68.00	43.98*	Companies with disruptive ideas, Growth of innovative companies, Researchers in R&D, R&D expenditure, university-industry collaboration, FDI and technology transfer, VC availability

*Computed based on the data from the countries presented in the report.
Source: EDGI, DESI and inCITIES

According to both EDGI and DESI, Norway, Finland, Sweden and Denmark are in the top tier of digital economies in EU/EØS [1, 3]. Additionally, the European region is far above the world average of 0.55 [3]. All the Nordic countries are also considered to be far above the EU average when it comes to 5G readiness. According the 5G readiness index, Finland is the front-runner when it comes to implementing 5G and its related technologies. However, Denmark is considered to have the best innovative landscape, but lags behind

on infrastructure and technology, being just above the EU average in this category [2]. It is important to note that all the indexes are based on country-level findings, hence, they do not reflect the state of digitalization in the individual municipalities.

Urbanization

The population growth rate strongly varies across the Nordic municipalities, with the largest cities and their surrounding areas having the highest population growth rates. The Nordic countries experience similar trends as the rest of the world, urban areas are experiencing a higher population growth rate than rural areas. In some cases, rural areas have even started to experience population decline. However, the concept of urbanization can be defined in multiple ways depending on the areas being compared. From the European perspective, the Nordic countries are sparsely populated. In 2016, only 45% of Nordic residents lived in what is defined as functional urban areas. On the other hand, more than 75% of Nordic residents lives in urban settlements with more than 2.000 inhabitants. Both functional urban areas and many urban settlements experience population growth. According to Nordregio [10], areas around Oslo, Stockholm, Copenhagen and Helsinki had the most intense population growth in the period 2011–2016. This includes municipalities situated within the functional urban areas that surrounds the largest cities.

The Nordic countries urban qualities in small and medium-sized cities have been prioritized as important areas of regional development. Even though people are moving to urbanized areas, it is not evident that urbanization is reserved the largest cities. Small and medium-sized municipalities have the potential to remain attractive places to live through development programs and municipal service improvement. Digitalizing to create better and seamless services might prove an important step for small and medium-sized municipalities to increase their attractiveness [37].

National and regional influences

All the Nordic countries are in the process of implementing national digitalization strategies where digital technologies are viewed as tools to realize local and national goals and focus on digitizing at a local level by responding to local challenges, needs and priorities [37]. However, there are significant differences in how the countries govern digitalization efforts on a national level [13].

The government structure in the Nordic countries is similar for all countries. It has a three level structure with national, regional and local authorities. Each level has a set of public responsibilities; however the responsibilities of each governmental level might differ among the countries. Similar to all countries is a high degree of local autonomy for the local authorities in the municipalities [38].

There are several national organizations that influences the direction and focus of digitalization within the municipalities. Each of the Nordic countries has a municipal association with the core task of advocating the interests and development of municipalities and their partner organizations [39–42]. In addition to the municipal organizations, all the Nordic countries have national agencies that advocate the direction of digitalization at a national level. In Denmark, Norway and Sweden, this position is hold by a dedicated national agency for digitalization. In Finland, however, it is the ministry of Finance that is considered to be the core policy provider for ICT and digitalization. However, there are some differences between these national digitalization agencies in the governance tools available. In Denmark, the Danish Agency for Digitalization has direct access to decision-making processes in municipalities, regions and state sectors through a budget negotiation role. While in Norway, Difi, is not directly involved but defines regulations and standards [13]. The municipal association also support the municipalities in digitalization by creating superior goals and strategies [39, 43, 44]. In Norway the Norwegian Association of Local and Regional Authorities (KS) and the Norwegian Ministry of Local Government and Modernisation (KMD) has formed and overall digitalization strategy for all governmental levels [45]. While in Denmark and Sweden, the municipal digitalization strategy is created solely by KL (Denmark) and SKR (Sweden). In Finland on the other hand, there is no agency which holds the overall strategy for digitalization within the municipalities. However, The Finish Ministry of Finance is considered to be the core policy provider for ICT and digitization [38].

Local Autonomy

The Nordic countries are characterized with regions and municipalities with high degree of local autonomy. In the European comparison, the Nordic countries distinguished themselves with a wide range of tasks and great organizational freedom. Local authorities in the Nordic countries have the freedom to organize themselves after local needs. Additionally, a large share of the municipal income is from local funding [38].

Overall, Finland is considered to have the highest degree of local autonomy among the Nordic countries. When it comes to interactive governance, Finish local authorities have a stronger position than local authorities in Denmark and Sweden, but not as strong as for local authorities in Norway. In Norway, the municipalities have lower fiscal autonomy compared to the other Nordic countries due to stronger national regulations on taxation. Norway also has the most limited scope of local democracy both when it comes to financial autonomy; the freedom of the municipality to control financial resources, and functional autonomy; the ability to control the objectives and the goals of the local government. However, Norway has the highest scores in interactive governance, meaning that local government has as strong influence on national policy-making affecting the municipalities. Both Danish and Swedish municipalities have high functional autonomy, however, Danish municipalities have a lower financial autonomy than Swedish [38].

Approach to public innovation

There are both clear similarities and clear differences on how innovation is approached in the Nordic countries. First, Sweden and Finland is considered to have a more overreaching and structural approach to innovation, while Denmark and Norway are more process and practical oriented towards tools to support individual organizations. Further, innovation projects in Norway are often activities outside daily service delivery, while direct development in operational activities has a larger focus in Denmark [45]. In Denmark, the Centre of Public Innovation support focus on innovation when public sector organizations collaborate with private actors. The organization also aims to increase the number of mature technological solutions and new technologies [46]. Vinnova is the Swedish public organization for innovation, Innovation Norway and The Research Council of Norway have the same responsibilities in Norway, and in Finland the project Experimental Finland focuses on pilot projects in the public sector.

4 Methodology

In order to answer the research question “How is smart city development is organized in medium-sized municipalities in the Nordic region?”, the multiple case study analysis is used as a research method. According to Yin [47] the case study is suitable to examine contemporary events. Further, the strength of the case study is its ability to deal with the full variety of

evidence such as documents and interviews Yin [47]. The aim of multiple case study analysis is both to test the validity of existing theory, and to add to existing theory based on empirical findings [17]. The methodology consists of selecting the appropriate cases, collecting the data and analyzing the data [17]. Each of the steps are described in the following sections.

Case selection

In multiple case study analysis, there are three main criteria for case selection; the cases should have characteristics which enables them to be viewed as one entity, a quintain, the cases should provide diversity across the context, and they should "provide the opportunity to learn about complexity and context" (p. 23) [48].

In order to fulfill the first criteria of [48], all the case-municipalities chosen are of medium-size. For this article medium-size is defined as population size of 20.000 to 60.000 inhabitants. This is selected as the unifying criteria for several reasons. First, the size interval is set to include case-municipalities which are large enough to have initiated their own smart city projects, but small enough to have different demographic, social and economic characteristics than larger cities. Second, as stated in the introduction, smart city development in medium-sized cities is less researched than in larger cities. Third, as elaborated in Section 3, the Nordic countries focus on development programs and service improvement in small- and medium-sized municipalities.

Table 2, shows the fraction of the country population who are living in medium-sized municipalities, as well as the fraction of the total number of municipalities which are of medium size. Even though most of the citizens of the Nordic region lives in what is considered to be large municipalities, a substantial fraction lives in medium-sized municipalities. Hence, the medium-sized municipalities are chosen for two reasons. First, because of their potential to remain attractive areas to live which diversify economic growth through regional business development. Second, because they face different challenges in terms of social, economic and environmental sustainability compared to larger cities [10].

Next, in order to provide diversity across context, one municipality from each of the countries Norway, Sweden, Denmark and Finland is selected. Hence, how smart city development in medium- sized municipalities is organized is mapped across country contexts. Even though the Nordic countries have many similarities in terms of social, economic and governmental factors,

Table 2 Medium-sized municipalities and their population as a fraction of total population

Size/Country	# Municipalitites population 20′–60′	% of total number of municipalitites classified as medium-sized	Population in medium-sized municipalities as % of total country population
Denmark	65/98	66%	48%
Finland	39/310	13%	23%
Norway	48/356	13%	29%
Sweden	85/290	29%	29%

they also have differences. Some of these differences are outlined in the background chapter in Section 3. The section describes that there are nuances in national and regional influences on digitalization, local autonomy and approach to public innovation.

Lastly, in order to consider the opportunity to learn about the complexity and context of smart city development, two selection criteria are considered. First, the municipalities are in a sample of ten promising municipalities from each country. The municipalities were pointed out as promising for smart city development by domain experts. Secondly, the municipalities use or have used some kind of smart technology, but do not need to have a smart city strategy. Out of the ten municipalities from each country, the municipality pointed out by the domain experts as the most promising in terms of smart city development was chosen. By selecting the leading cases the aim is to identify best practices for smart city development in medium-sized municipalities.

Data Collection

After settling on the case-municipalities, the websites of the municipalities were used to identify the digitalization or smart city leader in each municipality. Initial contact was made, the aim of the research was presented and a date for the interview was settled upon. Before the interviews, information about the four cases were collected through websites, reports and articles available online. Hence, we had knowledge about several areas of the smart city development in the selected cases before the interviews were held. Next, a one hour semi-structured interview were conducted with the smart city manager or digitalization manager in each of the municipalities. The interview template can be found in appendix A. Based on the template, the same general open-ended questions were asked in all of the interviews. However, minor adjustments to the interview questions were done during the interviews in order to make it more relevant for each case. The interviews were conducted

Table 3 Overview of interviews and secondary data

Data format	Description	Sources
Interviews	4 interviews with 5 informants from 4 municipalities	Development- and smart city department leaders IT-department leaders Mayor
Documents	National and regional digitalization strategies in the Nordic countries Reports comparing the Nordic countries on digitalization, innovation and governance	National governments, Nordregio, Norwegian association of Local and Regional Authorities, Nordic Innovation, Rambøll, Struense & Co
Statistical data	Digitalization and smart city indexes Municipal statistics in the Nordic countries	EU, UN, inCities Consulting, IMD World Competitive Center, Eden Strategy institute Statistics Norway, Statistics Finland, Statistics Denmark, Statistics Sweden

in April 2020. For the Norwegian case-municipality, our interviews supplement previous interviews, conducted in 2019 by the connectivity company Telenor. All municipalities also received a follow up e-mail with questions to be answered to supplement the analysis. All the digitalization managers responded to this email.

According to [48], the context in which the cases appear, influences the choices made and the activities initiated within each case. Thus, in addition to the interviews, secondary data about national and regional influences has been collected. This includes global, European and Nordic digitalization indexes, national digitalization strategies for the Nordic countries, and different reports on the state of smart city development and digitalization in the Nordic countries. Table 3 gives an overview of the type of data collected, as well as the related informants and authors.

Data analysis

According to Yin [47], following theoretical propositions is the preferred analytical strategy for case study research. Thus, in order to answer the research question "how is smart city development organized in medium-sized municipalities in the Nordic region?", an analytical framework has been established. The framework was created to be able to organize and compare the empirical data from the four cases, and was established by considering the applicability of existing theoretical frameworks to the empirical data. Based on the assessment of the applicability of previous theories, we settled

Table 4 Dimensions and sub-dimensions of the analytical framework

Dimension	Sub-dimensions
Smart city concept	Human-centric, Technological, Integrative, None
Smart city governance	Goals and strategies, project initiator, organizational setup, project selection criteria, motivational drivers
Smart city collaboration	Businesses, academia, citizens, inter-municipal, regional and national, strategic facilitator
Smart city resources	Mobile network deployment, financing

on four dimensions with related sub-dimensions. The four dimensions are; the municipalities' understanding of the smart city concept, smart city governance, smart city collaboration and smart city resources. An overview of the analyzed dimensions and their related sub-dimensions is shown in Table 4. The subsequent paragraphs explain the relevance of each dimension to the research question.

The municipalities' understanding of the smart city concept is relevant for how smart city development is organized in the municipality as it affects the priorities of the municipality when it comes to smart city development. This especially has an effect on the municipalities without a clear orientation on the smart city concept, and thus do not see the relevance of the concept for their territories [23]. The municipalities' understanding of the smart city concept is viewed to be either technological, human-centred, integrative or non-existent, where each type of understanding result in different priorities. Furthermore, this dimension is of interest as small, medium and large municipalities tend to interpret the smart city concept differently [23].

Smart city governance is defined by the institutional governance structure and impacts the sources and use of resources for smart city development in the municipality [15]. Further, the output of the governance is the activities performed in relation to smart city development [26]. Hence, smart city governance provides valuable information to how smart city development is organized. According to Lee et al. [15], the important sub-dimensions to map when it comes to smart city governance is leadership, strategies, management processes and performance measurement. These dimensions of governance has been studied in larger cities, but how smart city governance is organized in medium-sized cities is less known. Hence, in the smart city governance dimension, we identify the presence of a smart city strategy, as well as short and long term goals. In terms of leadership, management processes and performance measurement we identify the project initiator, the organizational setup as well as project selection criteria. Additionally, we map the motivational drivers for smart city development in each municipality.

In addition to the municipal governance structures for smart city development, collaboration with external actors is an important aspect in terms of how smart city development is organized [37, 49]. The actors include those in the quadruple helix [26], which in addition to the municipality are businesses, academia and citizens. Further, horizontal relationships in the form of inter-municipal collaborations were mapped as such collaborations has been identified to appear when municipalities with more limited resources do smart city development [22]. Additionally, collaboration with regional and national actors were mapped to also include vertical collaboration aspects [49]. Additionally, we mapped the presence of a strategic facilitator for smart city development.

Lastly, the smart city resource dimension was added as resources in general are regarded as critical for value generation [50], and is thus considered to be an underlying factor for smart city development. Additionally, smaller municipalities are characterized with more limited resources than large ones [21]. Hence, smart city resources are of relevance to how smart city development is organized in medium-sized municipalities. More specifically, core assets for smart city development are resources such as information technology and financial resources [51]. In our analysis, we have focused on the mobile network deployment, and more specifically deployment of networks designed for IoT-implementation. In the financial resources dimension, we have focused on how smart city development projects are funded.

Case Descriptions

DM is located in a rural region of Denmark and has a population of approximately 50.000 inhabitants living in several urban settlements within the municipality. Green industries are important contributors, and several green industry players have facilities located in the municipality. The main part of smart city development in DM has evolved around a founded project in one of the municipal villages. However, the project was ended before it was finished due to lack of political support. Many of the sensors installed during this project is now out of order, however the LoRa-network installed during the project is still active. The municipality do not have a smart city strategy, but smart technologies are mentioned as a part of the development strategy. Currently, the municipality only has one smart project within elderly care which is in a very early pilot stage.

FM also has a population of approximately 50.000 inhabitants and is situated close to multiple larger cities, in an urbanized region of Finland.

The ICT industry has a long history in the municipality, and today the municipality has an IoT-campus housing academic institutions, as well as R&D facilities and production areas for companies. Initially, the main focus of smart city development in the municipality was to create jobs. However, the municipality has recently started to focus on more citizen-centric perspectives of smart city development. The municipality has a smart city strategy, a long term goal for smart city development and multiple ongoing smart city projects.

NM has approximately 30.000 inhabitants. NM is located in an urban region of Norway, close to a large city. The most important industry players in the municipality are engineering, wood processing and pharmaceutical industries. The Smart city-program of NM stimulates experimentation, testing and demonstration of new technology, new services for citizens and new types of business models to create value for a more forward-looking society. Hence, the municipality both has a smart city strategy and a long term goal for smart city development. Currently, the municipality has multiple ongoing smart city-projects.

In *SM* there lives approximately 40.000 people. The municipality is situated in a rural region of Sweden, but close to a large city. Important industries in the municipality are wood industry, metal- and engineering industries. The Swedish municipality is mainly focused towards digitalization and do not have a smart city strategy, nor projects which they define as smart city projects. The municipality has focused on creating a municipal platform that enables the municipality to collaborate on digitalization projects with other municipalities. The platform includes collaboration with other municipalities on system maintenance and broadband infrastructure. In terms of smart city-related projects, an energy provider in the municipality has built a LoRaWan-network, which is currently only for testing purposes.

5 Analysis

The analysis consists of four dimensions with related sub-dimensions where the aim of each dimension is to describe different aspects of how smart city development is organized in medium-sized municipalities in the Nordic region. First, the understanding of the smart city concept is analyzed. Next, aspects of smart city governance is analyzed to describe how smart city development is organized internally in the municipality. Then the municipalities' relationships with external actors are presented, focusing both on external actors in the quadruple helix and public horizontal and vertical relationships.

Lastly, the smart city resource analysis maps the state of the mobile network deployment and the financial resources for smart city development in the municipalities.

Understanding of the smart city concept

How the municipality understand the smart city concept might have an effect on how smart city development is organized. As presented in Section 2.2, the municipal understanding of the smart city concept might set the priorities and direction of smart city development. Hence, the under- standing of the smart city concept of each of the case-municipalities is outlined in this section.

It is challenging to give a precise description of the understanding of the smart city concept in the Danish municipality. In the interviews, DM defines smart city development as a way of improving the quality of life of citizens by focusing on the citizen's needs. Sensors and network deployment in the municipality is only considered smart city if it creates value for citizens. Smart city development is viewed as a means to make citizens stay in the municipality and not move to larger cities. This view is in line with a societal view of the smart city concept where the municipality aims to become a smart city based on people, sustainability and governance [23]. However, the municipality chose to end their smart city initiatives due to lack of political support and change in administrative priorities.

Historically, the Finnish municipality has had technological view of smart city development. The municipality defines smart city as way of using technology to solve problems. This technological view of smart city development is rooted in the presence of strong ICT industry in the municipality. However, FM has recently started to include the softer sides of smart city development, in example that data can be analyzed for the sake of well-being of the citizens. The municipality was introduced to the societal perspective of smart city development when participating in a Nordic collaboration program for municipalities.

The Norwegian municipality NM has an integrative view of the smart city concept. The focus of smart city development includes lowering costs of municipal services, provide work for citizens and also provide projects for startups. The municipality also add short and long term sustainability as an important aspect of smart city development. Lastly, citizen engagement in development projects is considered to be important. Hence, both the technological and societal aspects are considered in the smart city development.

The Swedish municipality SM do not define themselves as a smart city. They do not consider smart city as an applicable concept to their municipality. In their view, smart city development is more fit and easier to run in larger cities. However, the recent focus of the municipal administration has been to create a strong platform for digitalization and development of municipal services. Further, the municipality has some projects involving smart technology. However, these projects are not branded as smart city.

Governing smart city development

In the smart city governance dimension, we analyze how smart city development is organized internally in the municipalities. We analyze the presence of a smart city strategy and the short and long term goals. Further, in terms of leadership and management processes, we identify the project initiator, the organizational setup as well as project selection criteria. Lastly, the motivational drivers for development in the municipality are analyzed. An overview of smart city governance in the Nordic municipalities is shown in Table 5.

DM has no long term or coherent smart city strategy. However, the municipality has an overall development strategy which includes goals of improving the digital infrastructure and using smart technologies to develop municipal services. The organizational setup for smart city development is considered to be unorganized, there is no structure and no one with a dedicated task of smart city development or exploring new technology. Each municipal department is responsible to identify how new technology can be used in their department. However, the different departments in the municipality have to involve the ICT department for all digitalization projects to make sure that security and open data requirements are met. DM considers both the quantitative and qualitative value contribution when initiating new projects. The main motivational drivers for smart city development in the municipality is to increase service to citizens in a sustainable and economical way, as well as providing the same quality of service at a lower cost. DM also has challenges related to an aging population, however, this is not explicitly mentioned as a driver for smart city development.

FM has a smart city strategy focusing on smart mobility an transportation concepts as well as living environment concepts. The municipality is known as a great location for businesses to do smart device R&D, however the goal of the municipality is to also be known as a smart city. However, no coherent smart city program has been launched. Only one person works full

Table 5 Overview of smart city governance in the municipality

Municipality	DM	FM	NM	SM
Smart City Strategy	No*	Yes	Yes	No
Long term goal	Yes	Yes	Yes	No
Project initiator	The municipal departments	Companies	Companies, academic institutions, the municipality	Local company
Organizational setup	Unorganized, Projects need to be approved by the digitalization and ICT department	Unorganized, one person working full time on smart city development	A central project group as well as project leaders within each department	Non-existent for smart city
Project selection criteria	Projects are selected based on its potential for value capture, both qualitatively and quantitatively	Low budget, Small projects, Aligned with everyday goals	Sustainable, collaboration with multiple actors, uses technology in an innovative way	Development projects are prioritized by a committee
Motivational drivers	An aging population, Increase level of service to citizens, Provide the same quality of service at a lower cost	Create new jobs, attract new citizens	An aging population, increase level of service to citizens, provide the same quality of service at a lower cost, environmental friendly solutions, business development	An aging population, Depopulation, Provide the same quality of service at a lower cost

*The municipality do not have a smart city strategy, but smart technologies are mentioned as a part of the development strategy.

time on smart city development, but around 10–15 people touch upon smart city development in projects or their everyday work. In terms of initiating new smart city projects, it is the companies that approach the municipality with new ideas. Smart city projects are selected based on budget size and alignment to everyday goals. The municipality prefers projects of low budget due to limited financial resources. The experience is also that smaller projects are less affected by political agendas in the municipality, and are easier to complete. The motivational drivers for smart city development in FM is mainly to create new jobs.

NM has worked systematically through the years to develop its smart city strategy. The smart city program in the municipality was initiated as a consequence of a poor financial state of the municipality. In order to improve the financial situation of the municipality, NM hired experts on smart city and

digitalization to establish new goals and a new direction for digitalization. Today, the long term goal of smart city development in the municipality is to develop a sustainable, modern society where economical, social and environmental values are at the centre.

Further, NM has focused on having a clear and structured setup of the smart city program. The program has both a central project group under the development department, as well as project leaders for smart city development in the different municipal departments. The project leader in the department is responsible for the progression of the innovation efforts in the department, whereas the central project group is responsible for communication between departments and for making superior strategic decisions. Smart city projects are selected based on a set of overall criteria, namely being sustainable both in the short and long term, the project has to involve multiple actors and technology has to be used in an innovative way. In addition to the overall project selection criteria, the different project ideas are scored in order to make them comparable for selection. The municipality has recently started to use a digital platform where all project ideas and their related score can be found and the progress of initiated projects is tracked. The motivational drivers for smart city development was initially to lower the cost of service provision in the municipality. However, the motivational drivers have evolved to include business development in the municipality, handling an aging population and increase the level of service to citizens.

As mentioned, SM do not consider themselves as a smart city, and they do not have a smart city program. However, the municipality have a clear strategy for creating a municipal platform for digital development. The platform have three main areas: (1) Collaboration with multiple other municipalities on the development of e-services, (2) System maintenance to handle security issues and (3) Development of infrastructure and broadband network deployment. When this platform is set, SM views itself as able to initiate larger projects. However, the municipality has not yet defined any goals which measures the effect of initiated projects and changes. Digitalization and organizational change is organized as a dedicated project office with a project manager leading the office. However, the municipality do not have something similar for smart city development. New development projects are selected by a committee which prioritizes the projects. Other projects are decided by the different departments or by politicians depending on the scope. The motivational driver behind digitalization in the municipality is to cope with challenges such as an aging population, depopulation and creating more efficient services.

Smart City Collaboration

The Smart City Collaboration dimension analyzes how collaboration with external actors is organized in medium-sized municipalities. Both collaboration with quadruple helix actors and public vertical- and horizontal relationships are analyzed. Collaboration with quadruple helix actors refers to collaboration with businesses, citizens and academic institutions. While public horizontal relationships refers to how the municipality collaborate or coordinate with other municipalities. Public vertical relationships refer to how the municipalities get support, collaborate or coordinate with regional and national public organizations. An overview of how collaboration with external actors is organized in the four case-municipalities is given in Table 6.

Smart city collaboration in DM

In terms of collaboration with quadruple helix actors in smart city development, DM has collaborated with both businesses, academic institutions and citizens. DM has collaborated with both small and large companies on smart city development. However, they find it easier to collaborate with smaller companies because the distance from idea to decision is shorter in such collaborations. Collaboration with universities includes projects where researchers get the opportunity to test technology in the municipality and student projects where the students design services for the municipality. Further, the municipality interact with citizens on digitalization projects using questionnaires and seminars.

DM also coordinates and collaborate in inter-municipal networks and get support from regional and national public organizations. However, collaboration with other municipalities is considered to be unstructured. The municipality do participate in an inter-municipal forum with 17 other municipalities in the region. Representatives from the municipalities meet 3–4 times a year to ex- change general experiences and to make policies on how to treat and implement services of private actors. In terms of national and regional collaboration, DM is in the early phase of establishing a smart device project in the health sector in collaboration with the municipal innovation organization KOMBIT. Additional national support is first and foremost related to the national broadband and connectivity strategy which aims at improving the digital network deployment in all Danish municipalities. Regionally, the municipality participates in a partnership network for knowledge sharing. Participating actors are municipalities, businesses and knowledge and research institutions. The main goal of the partnership is to ensure green

Table 6 Overview of collaborating actors on smart city development

Actor	DM	FM	NM	SM
Strategic facilitator	None	None	Hired experts to help develop the digitalization and smart city strategy	None
Businesses	Finds it easier to work with small companies	IoT Campus, Prefer to collaborate with local companies as partners for innovation	Large companies considered the most important partners for innovation	The local energy company
Academia	Universities invited to test technologies, Student projects	Collaborates with two universities in neighbour municipalities.	Research projects, student projects	IT-programs in local higher vocational education
Citizens	Workshops	Questionnaires, Workshops	City Lab, Questionnaires	No specific communication for smart city development
Inter-municipal	Unorganized, participates in a forum for exchange of experiences with 17 municipalities	Unorganized, participation in an inter-municipal forum of Nordic municipalities	IoT-project with neighbour municipalities, Regional common IT-architecture project	Non-existent for smart city development, Collaborates with multiple other municipalities on digital service solutions
National and regional	KL/KOMBIT, National support on digital network deployment, Regional Partnership network	Kommunforbundet, Nordic smart city forum	KS, National smart city development support, National innovation programs	SKR, National smart city development support, National innovation programs

transition and growth in the region. However, the network also focuses on smart city and smart communities. Regarding smart city development, the main focus of the network is to discuss new technologies and how they can be implemented. However, few representatives from DM has participated in the network.

Smart city collaboration in FM

As in DM, FM collaborates with all actors in the quadruple helix where most of the helix collaboration is centered around an IoT campus in the municipality. The campus is an arena where businesses can meet, and it has both production areas and R&D-facilities. The goal of the campus is to create a good surrounding for innovating new ideas. Some of the companies located at the IoT campus also work with the municipality to test the technology of the company and innovate together with the municipality. Further the IoT campus also houses scientists and educational institutions. The municipality collaborates with universities in neighbour municipalities, and one of the universities also has facilities and study programs situated in the IoT campus. Regarding citizen engagement, the municipality uses both questionnaires and workshops. However, FM experience that citizens are not able to give good answers on the spot. The municipality find citizen engagement challenging because they are not able to engage the citizens in the initial phases of a project, which sometimes result in complaints when the effects of the project becomes visible.

Similar to DM, FM's collaboration with other municipalities is unstructured. However, the municipality looks internationally for inspiration to smart city development. When the municipality created the IoT campus, they looked internationally to similar facilities to get inspiration. The municipality has also participated in a smart city program together with other municipalities in the Nordic countries. Further, the municipality plans to collaborate with the local telecommunication company which has several municipal owners on a smart city project. Nationally, the Association of Finnish municipalities provides a platform for benchmark purposes and knowledge sharing. The solution can be used to communicate with other municipalities. The municipality can both present its results and achievements, but also ask other municipalities about their experiences. However, FM report that they have not had the capacity to use the platform actively. The municipality has also participated in a Nordic smart city forum with one municipality from each of the Nordic countries. It was through this forum, that the municipality adapted a more human-centric under- standing of the smart city concept.

Smart city collaboration in NM

In contrast to the other municipalities, NM has for many years collaborated with a facilitating organization providing support for smart city development. The facilitating organization has helped the municipality to plan, initiate and implement their smart city-program.

Further, NM also collaborate with all the actors in the quadruple helix. Both academic institutions and companies approach the municipality with smart city projects where they want the municipality as a partner. Hence, the municipality has to prioritize requests for new projects. In terms of partners for innovation, the company prefer to collaborate with large actors, both private companies and academic institutions. However, this is partly because there are few local companies delivering services for such projects. In terms of collaboration with academic institutions, the municipality collaborates on both research projects and student projects. Further, citizens have been engaged by using questionnaires. The goal of the questionnaires is not to find new projects, but to help the municipality guide selected projects in the right direction. However, the municipality has also recently opened a City Lab. This facility is supposed to be an overall organization for smart city, but also an arena for citizens to participate in smart city development.

When it comes to collaboration with other public actors, NM has several inter-municipal collaboration projects. The municipality has collaborated with two neighbouring municipalities on an IoT project. Further, the municipality is part of a formalized collaboration network where municipalities in the region are collaborating to create a common IT-architecture. The organizational setup for this collaborative project is a secretary of three people, a steering group where all the municipal counselors are present and a coordination group consisting of digitalization-leaders and directors in the municipalities. The goal of this collaboration is to create a common IT-architecture. The project has proved to be challenging as it limits the type and amount of individual projects a municipality can do.

Smart city collaboration in SM

In relation to smart city development the only project of SM is the implementation of a LoRa-network done by the local energy provider. However, this section also outlines the municipality's relationships to external actors on digitalization, as it can prove relevant for smart city development in the municipality in the future.

For digitalization, the municipality collaborates with both businesses and the local higher vocational school. Regarding collaboration with businesses, SM considers it as easy to build networks of organizations and companies. One example is a 5-year development program where local businesses and the municipality together created a strategic document that describes what is expected by the local businesses and what is expected by the municipality.

Further, a set of IT-study programs were established at the local higher vocational school in order to meet the need for more digital competence both among local companies and the municipality. Today, the higher vocational school educates digital specialists which are recruited both by the municipality and the local companies. The municipality further has some communication with universities in neighbouring municipalities, however, this is more focused towards general municipal development and education. In terms of citizen participation, the municipality has continuous citizen dialogue and a routine for citizen engagement and ideas, but do not have specific programs for citizen engagement related to smart city development or digitalization.

SM collaborates both vertically and horizontally with other public organizations for digitalization, but not for smart city development. Regarding inter-municipal collaboration in the field of digitalization, SM participate in a national network of municipalities where project ideas and experiences are shared. An advantage of the network is that it provides the municipality with ideas from municipalities located far away geographically. In example SM has, by being a part of the network, discovered a digital process, developed by another municipality, which it wants to buy. In addition to participation in the national network of municipalities, SM collaborates with multiple neighbouring municipalities in the region on developing e-service solutions. Regarding vertical relationships, the national municipal association SKR supports SM by providing the municipality with recommendations on standardization and how to build the municipal infrastructure. However, they do not provide plug-and-play solutions, which have to be developed locally.

Smart City Resources

The last dimension of the analysis is the availability of resources for smart city development. According to Wirtz et al. [51] the core assets for a municipality to become smarter is the information technology infrastructure and the financial resources. Hence this section outlines the mobile network deployment and the financial resources available for smart city development in the municipalities. Table 7 gives an overview of the mobile network deployment for smart technologies in each municipality.

Mobile network deployment

In DM, broadband network connectivity for citizens is still under construction in the rural parts of the municipality. The municipality is behind many other

Table 7 Overview of sensor networks in the municipalities

Network	DM	FM	NM	SM
LoRaWan	Yes	Yes	No	Yes
NB-IoT	Yes	Yes*	Yes	No
Sigfox	Yes	No	No	No
5G	Planned	Planned	Planned	Unknown

*The network is currently for R&D purposes.

danish municipalities on broadband connectivity, but a new fiber network is currently under construction. There are, on the other hand, several actors providing LPWAN-networks that meet the IoT requirements. The municipality has several applications are currently being processed for 5G and narrowband antennas. In addition, the municipality has a LoRa-network used to transmit data related to district heating in one of its villages. Lastly, the Danish Sigfox operator IoT Denmark has deployed its LPWA-network in the municipality.

FM has a LoRa-network initiated by a local company. However, the network is still in a testing phase where it is used for experimental purposes. The network has been deployed as a mutual test project; the municipality provides locations for LoRa-antennas, and data which the provider can test the network on, while the municipality transmits the data for free. There are also companies testing NB-IoT technology in the municipality, however, they have their own RD facilities and has not involved the municipality in their projects.

NM has installed a NB-IoT network in order to transmit data from sensors in the municipality. Currently most sensors connected to the network are only used in pilot projects for smart city development. However, the sensors are used in multiple different municipal departments such as water and sewage, renovation, air quality and pollution. Deployment of fiber networks in the municipality is challenging because of the scattered settlements outside the city centre.

SM has a LoRa-network built by the local energy company. The network is still in a R&D phase where the company is doing different pilot projects and tests with a lot of different suppliers and companies. The goals is to be able to do larger projects in the future. The deployment of the network is outsourced to the energy company, which also make the strategic decisions. In example, the municipal administration was not involved in the choice of network technology. The broadband infrastructure in SM is considered to be well-deployed, broadband network deployment is expected to be finished in short time.

Financial resources and funding

In term of financial resources, projects in DM are funded by the different departments, and there is no dedicated funding for smart city projects. However, the departments can apply to the municipal board for funding if the business case of the project is good. The municipality has received funding for a large scale smart city project involving multiple actors. Sometimes public utilities that provide services to the municipality also contributes with funding to smaller projects.

FM has few financial resources for smart city development. The municipality also prefer smaller smart city projects that are considered as innovation projects where the procurement process is less regulated. However, regional or national organizations might support smaller projects. The municipality has received national funding for digitalization of governance.

NM uses test projects and innovation projects as an opportunity to spend less of the municipal budget on innovation projects. Companies test their technology with the municipality, but the municipality do not necessarily need to invest from their own budget in the project. The municipally has also received funding from national or regional innovation- and regional innovation programs.

Most projects in SM are financed by the organization initiating the project, however, some projects are financed by the municipality centrally. In both cases, the municipality aims at applying for external financing, as well as external collaboration if possible. Proof-of-concept and early test projects can also seek financial support from development budgets.

6 Discussion

The aim of this paper is to analyze how smart city development in Nordic medium-sized municipalities is organized and assess how it is influenced by contextual factors. Our aim has been to take a coherent approach by analyzing the governing and collaborative structures of smart city development in the selected cases. In this section, we compare our results to existing literature on smart city governance. Additionally, we discuss the contextual factors local autonomy, local conditions and the country-level approach to public innovation and digitalization.

Governing smart city development – cross case comparison

Previous literature on governing smart city development enhances the importance of a clear strategy, expectation management and communication both

internally and among all stakeholders in order to succeed with the implementation of smart city projects [12, 25, 28]. The empirical findings from our selected cases support this view, and it becomes clear by comparing the differences in how smart city development is governed.

The maturity of the smart city development differs among the four cases analyzed. This becomes evident by relating our empirical findings to the study of Ooms et al. [26], which traced the evolution of governance structures in a dutch smart city initiative. An important finding is that the governing of smart city development changes over time. In the initiation phase, the focus of smart city governance should be on building relationships, while the growth phase increases the need for setting, advocating and checking performance measures [26].

First, the project initiator might influence the strategic direction of smart city development in the municipality. In three out of four municipalities, private companies are the initiator of new projects. According to Gohari et al. [12], the interest of private sector partners in smart city development is innovation, economic interest and increased knowledge about their technology. Furthermore, Dameri [28] argue that private companies might neglect the needs of the citizens, prioritizing their own technical solutions. Hence, the municipality needs to have the organizational ability to ensure that public interests and citizen needs are met in the initiation phase of the project.

This enhances the importance of the municipality taking the lead of smart city development, setting clear goals and strategies to establish formal platforms for collaboration [12]. The alternative, informal networks with fragmentation of responsibilities, make smart city planning complex, ambiguous, and uncertain [12]. Both in FM and NM, private companies approach the municipality with new ideas for projects, and in SM, a local company has taken the lead on the only smart city project initiated. However, the municipalities ability to establish formal platforms for collaboration differ. NM has a central smart city leader and committee, as well as smart city project leaders within each municipal department, and is using a digital project evaluation tool to track the progress and performance of initiated projects. FM on the other hand only have one person dedicated to smart city work, and the smart city leader reports lack of focus on smart city in other parts of the organization. Lastly, SM has created a platform for collaboration among 14 municipalities on digitalizaton projects, and see this as a foundation to further built on. However, their only smart city project, implementation of a LoRa-network, is solely driven by the local energy company which makes the strategic decisions. Hence, SM do not take the lead on smart city development

in the municipality, even though they have a strong collaborative platform for digitalization. The degree of a formalized organizational setup in NM suggest that the municipality has entered the growth phase of smart city development, while FM and SM is in an initiation phase.

According to Ooms et al. [26], municipalities with smart city ecosystems in the growth phase has governance elements linked to transactional leadership. This includes co-creation strategies, dedicated formal organizations for smart city and large focus on performance measurement. Further, the importance of more formalized governance in the growth phase might be important to be able to handle more complex challenges. NM states that their main upcoming challenge for smart city development is related to storing the data when the number of sensors go from a few tenths to several thousand, and coordination of several data sources is needed. Hence, the formality of the governance structures might be of importance in order to handle the interests of all stakeholders when the complexity of the technology and systems used for smart city development increases.

Another interesting finding is that NM has, unlike the other municipalities, used a strategic facilitator to establish both a smart city- and a digitalization strategy. Hosseini et al. [21] argues that small towns in Germany, which are comparable to medium-sized municipalities, require stronger guidance than large cities to define the appropriate smart city strategies. We argue that the use of a strategic facilitator in the initiation phase might have accelerated the smart city development into the growth phase and ensured a more continuous process of smart city development in NM compared to the other municipalities.

FM, on the other hand is in an early stage of smart city development, however, the municipality has several characteristics to succeed in their efforts to become smart. The initiation phase of smart city development involves sensemaking, resource-gathering and establishment of organizational structures [26]. The enabling governance elements in the initiation phase should be to strengthen internal relations, cooperation strategies and goal setting. FM has both a common goal and a joint strategy for smart city development. Additionally, in terms of cooperation strategies, the IoT campus located in the municipality can be considered an innovation cluster [52]. Firms and organizations involved in clusters have been found to be more dynamic than those outside, and the proximity effects of the cluster can "improve the competitiveness of both the group of participants and the territory of its location" (p. 118) [52]. Hence, the presence of the IoT campus might prove itself a valuable resource for further smart city development in FM.

However, because only one person is dedicated to smart city development in the municipality, only small projects with low budgets and few actors are chosen. In order for the municipality to enter the growth phase of smart city development, the establishment of a formal organization for smart city development might be needed [15, 26].

Additionally, FM sees project scaling as the main inhibitor for advancing smart city development where smart city innovations and procurement of large scale solutions are two disjoint and separate processes. The issue of scaling smart city projects has been problematized by Taylor Buck who states that smart city development "overlooks the roll out of the smart city through multiple incremental and smaller steps" (p. 504) [53], and that "evidence suggests that smart city innovation is most evident through well-funded niche experiments in a limited range of urban contexts" (p. 504) [53]. Based on the empirical findings in FM, we argue that project scaling require increased attention in the initiation phase of smart city development in order to create projects that are not terminated at a piloting stage.

In the case of DM the smart city projects were ended due to lack of political support and co-ordination among the participating actors. Some of the initiated innovation projects in the smart city program were integrated in the municipal operations. However, most of the projects ended in its pilot phase. This can be explained by the lack of process owners, horizontal accountability and cooperation among all involved parties [25]. This is supported by Dameri who states that "Without a central direction, coordinating the interest of all the key actors with the stakeholders expectations and needs, the smart city will remain an interesting innovative laboratory, but failing in creating public and private value for all in the long term" (p. 2979) [28]. The measures taken to overcome these challenges should be comprehensive, integrated strategies to support long-term profitable and effective smart projects [28].

In conclusion the empirical and literature findings suggest that smart city development is dependent of the maturity of smart city governance in the municipality. In order for the case-municipalities to succeed with smart city development in the long term, clear goals and strategies, as well as platforms for collaboration are needed. In addition, support from a strategic facilitator in establishing the goals and strategies might be of importance for medium-sized municipalities due to their more limited resources. In addition, a strategy for scaling pilot projects needs to be present from the start, this way the smart city projects are more likely to create value in the long term and not remain experimental projects with limited impact.

The influence of contextual factors on smart city development

In this section we discuss to what extent contextual factors might have an effect on the smart city performance of the case-municipalities. We compare our findings to results from country-level reports regarding local autonomy [38, 54], approach to public innovation [45], and the national digitalization ecosystem [13]. According to Ruhlandt [2018], the influence of contextual factors on smart city development remains unclear, and few papers "mention, theorize or examine the potential role of contextual factors on smart city governance" (p. 9) [49]. However, the author's extensive literature review address local autonomy and local conditions as factors that appears to influence smart city governance.

Smart city governance is "argued to be influenced by many factors, most notably by the degree of autonomy or sovereignty a city possesses" (p. 9) [49]. Local autonomy is an important contextual factor as it is a foundation for local government effectiveness [38]. Comparing the empirical findings with findings from a British study, which explores the opportunities and tensions in practical realization of Smart city development in British cities [53], it can be found that local authorities with limited local autonomy is less able to innovate. In contrast to municipalities in the Nordic region, the local autonomy of local authorities in Britain is low. In the case study of Taylor Buck and While [53], cities were expected to innovate within short timescales, budget cuts, and with reduced local government power and influence [53]. Hence, the study showed that local authorities with low autonomy was not properly equipped for the complex task of smart city development and innovation.

However, in the Nordic region the local autonomy of the municipalities is considered to be high [38]. Digitalization is to a large extent decentralized, and at a local level, the municipalities are the leading entity for new digitalization projects [54]. However, the empirical findings from the Nordic municipalities give mixed results in terms of the advantages and disadvantages of local autonomy for smart city development in medium-sized municipalities.

According to Hosseini et al. [21], smaller communities have the advantage of a less complex infrastructure and network of actors compared to large communities, enabling them to move faster with innovative efforts. The findings of this study support this statement, the Nordic municipalities have initiated and facilitated innovative smart city projects in collaboration with triple-helix actors. Especially the less formal conditions in the initiation phase

of smart city development give the municipality the opportunity to initiate exploratory smart city projects without having to consider central regulations and standards. However, as discussed in the previous section, the Nordic medium-sized municipalities sometimes struggle to meet the requirements of the formal organizational setup that is required to scale projects from a piloting or exploratory phase into solutions used in daily operations.

The challenge of scaling might be related to smart city development being a complex matter which requires large technological insight and competence. In Norway, only 40% of public authorities report that they are able to collect, sort, utilize and share data about citizens [55]. Moreover, Kaupang [56] found that both Norwegian municipalities and the central government see the need for more regional and national coordination on digitalization. Yet, it cannot be guaranteed that centralized steering leads to better performance on smart city development. In example is the governing of digitalization more centralized in Denmark than in the other Nordic countries, with a central unit for strategic management and tactical organization. The organization sets a clear agenda which the municipalities must follow, but the organization has not been able to optimally facilitate and support municipal projects and value realization in the municipalities [54].

Hence, there is a paradox between centralization and decentralization of smart city development. On one note, innovative solutions developed to fit to local needs might emerge from exploratory smart city projects in the less formal local context of medium-sized municipalities. Yet, with regional and national coordination and support, the municipalities can benefit from economies of scale and shared competence among the municipalities [54]. In order to handle this paradox, close collaboration among the governmental levels and clearly defined roles are needed. In one example, Statens Vegvesen [57] suggest that the type of services provided is decided by the municipality, while the technical requirements, interfaces and formats are decided either by regional or national organizations.

In addition to local autonomy, the literature review of [49] found that local conditions might also affect smart city development. Meijer [58] identifies two contextual variables that might impact smart city development. The variables are local knowledge potential and the nature of the problem domain. First, local knowledge potential considers the fit between new technology an the attitude of the relevant actors. Second, the nature of the problem domain considers such as democratic institutions and culture, physical environment and economic production. Further Nam and Pardo [59] found that scarcity of resources could be an imperative for initiating smart city projects. In

both FM and NM, smart city development was initiated as a consequence of poor economic conditions. The financial state of NM had been poor for many years, and they saw that they needed to change in order to improve the situation. The solution was to set ambitious goals to become a leading municipality in digitalization and smart city development. In FM, the loss of a cornerstone business forced the municipality to rethink their strengths and properties. The solution was to use existing facilities of the cornerstone company to build the IoT campus. Hence, the case of NM and FM shows that changes in local conditions such as economic performance do impacted the attitude towards smart city development.

In addition to local autonomy and local conditions, we argue that the national approach and regulations to innovation (see section 3) can be considered a contextual factor which might impact the smart city development in the municipality. Regarding the approach to public innovation, Norway is considered to have a practical approach where innovative projects are initiated outside daily service delivery and municipal department budgets [43]. The fact that public in- novation is focused towards facilitating and ensuring the success of individual projects, might be an enabling factor for smart city development in medium-sized municipalities due to their more limited budgets, and fewer opportunities to collaborate with multiple ecosystem actors [21]. In Denmark on the other hand, innovations are supposed to happen within the limits of daily operations with no separate budget for innovation [43]. The empirical findings suggest that this might inhibit smart city development as it requires the individual departments to initiate new projects in addition to their daily tasks. However, the effect of the national approach to public innovation is an area of research that needs to be further studied.

Last, an interesting finding from the case studies is that even though Norway reach the lowest scores in all the indexes examined, it is the Norwegian case-municipality which has the most organized setup and the most formal approach to smart city development. We therefore argue that contextual factors do have an impact on smart city development. An hypothesis is that the higher scores of Finland, Denmark and Sweden in the digitalization indexes might be explained by high performance in central regions, while small and medium-sized municipalities are lagging be- hind. However, contextual factors in Norway might be better suited for smart city development in medium-sized municipalities. These conclusions are however, based on indices and requires further research in order to be confirmed.

7 Conclusion and Contributions

The Nordic countries stand out as digital front-runners in Europe as well as in a global perspective. Denmark, Finland, Norway and Sweden are all in the top-tier of many digitalization indexes. In addition, several Nordic larger cities are represented among the best performing cities in global smart city rankings. In order to map the state of smart city development in areas outside the larger cities, the aim of this article has been to map smart city development in medium-sized municipalities.

Thus, this paper has outlined the governance structure and the actors contribution to smart city development in four medium-sized Nordic municipalities. The findings suggest that the maturity of smart city development differs among medium-sized municipalities in the Nordic region. The findings suggest that, in terms of smart city governance, clear goals and strategies defined for the long term, as well as a formalized organizational setup for smart city development in the municipality is needed for smart city development to mature. In addition, support from a strategic facilitator in establishing the goals and strategies might be of importance for medium-sized municipalities to ensure a long-term focus on smart city development.

Further, the empirical findings from the case-municipalities has been placed in the context of contextual factors and country-level dynamics. The influence of local autonomy, local conditions and the countries approach to public innovation on smart city development in medium-sized municipalities has been discussed. It was found that there is a paradox between centralization and decentralization of smart city development, and that close collaboration and clearly defined roles are needed to both get the benefits from the local autonomy of the municipalities, and the synergy effects of centralized support and facilitation. The findings further suggest that local conditions such as economic factors and scarcity of resources act as a driving force to initiate smart city development. Last, the country-level approach and regulations on innovation might influence the smart city development in the municipality. However, more research is needed on this topic.

8 Limitations and Further Research

Despite this study's contributions, it does contain limitations. In this section we outline some of the limitations related to our study. In terms of methodological limitations, we have interviewed one or two people responsible for smart city development or digitalization in each municipality. However, other

views on the priorities for smart city development might exist in the municipality. Hence, in order to further map the state of smart city development in medium-sized municipalities an area for further research is to map the roles and interests of the leaders and employees in the municipal departments of medium-sized municipalities in order to understand how smart city development changes the organization.

Case selection based on a sample of municipalities from each country provided by domain experts. Hence, the medium-sized municipalities do not necessarily represent the most forward looking municipalities of medium-size. Hence, an area of further research is to quantitatively map the state smart city development in all medium-sized municipalities in the Nordic region.

Further, we have interviewed one case-municipality from each country as a starting point to understand the condition of smart city development in medium-sized municipalities in the Nordic countries. However, more cases should be examined in order to validate our results. Further, we have not focused on the potential of cross-country collaboration to improve municipal services. Given the quite similar characteristics of the Nordic countries, the potential of such collaboration for smart city development in municipalities is an interesting area for further research.

Last, we have discussed contextual factors and how they might influence smart city development in medium-sized municipalities in the Nordic region. However, we do not compare how contextual factors affect medium-sized municipalities compared to large municipalities. Hence, we suggest that more research is needed to further understand how contextual factors affect smart city development in small- and medium-sized municipalities compared to large municipalities.

Appendix

A Nordic municipal interview guide

Introduction

The interviewers present themselves and the topic of the thesis. The interviewers ask the inter- viewers to present themselves, their role in the organization and for how long they have held the position.

A1 – Overview of projects

- How do you define smart city-development in the municipality?
- How has smart city development advanced throughout the years, to where you are today?

- Which projects are considered smart city projects?
- Why are they chosen as smart city-projects?
- How are the smart city-projects in the municipality financed?
- How does this affect the project?
- What other digitalization/ICT-projects do the municipality have?

A2 – Goals, drivers and inhibitors

- Do you have a digitalisation strategy? Does it define goals and activities for further devel- opment?
- What are the long term smart city goals of the municipality?
- What activities do you do to reach the long term goals?
- Do you have a smart city/digitalisation strategy?
- Do you look outwards for smart city-inspiration? (regionally, nationally or internationally)?
- What factors made you look to these for inspiration?
- What do you consider as the main drivers for smart city development in the municipality? Which problems can be solved?
- What inhibits smart city development in the municipality?
- Are there any general and special challenges in this municipality regarding geography, socio- economic composition, population density, etc.?

A3 – Digital infrastructure

- What is the status for digital network deployment in the municipality?
- Do the municipality have a NB-IoT or LoRa-network?
- Who is the network provider?
- In what areas are the network used?
- How can ownership of infrastructure and management in the municipality affect the choice of ICT and IoT for the municipality's infrastructure and services?

A4 – National and regional support

- To what degree does national goals and regulations influence smart city-development?
- What kind of support do the municipality get from national and regional organizations to develop your smart city-projects? (E.g. competence, financial support, change, strategic)
- How do you cooperate with the national municipal organization?

A5 – Collaboration

- How do the municipality collaborate with other actors on digitalization - development? (Busi- ness sector, Academia, Citizens, Other municipalities)
- In terms of inter-municipal collaboration: Is there coordination / collaboration between different agencies with regard to the choice of solutions?
- What cooperation opportunities can you see within the municipality for common ICT- and IoT strategies for different infrastructures, in order to achieve eg. critical mass and scale advantages?
- What cooperation opportunities can you see between municipalities for a common strategy, for example when it comes to technology development, operation and organization of service offerings?

A6 – Innovation and Ecosystems

- Do you differentiate between smart city- and innovation projects? If yes, in what way?
- Which actors do the municipality see as relevant partners for innovation?
- What obstacles does the municipality see for cooperation on innovation projects?
- Do the municipality expect that digitization will bring changes such as the purchase of external services rather than solutions run by internal resources?

A7 – Gain Realization

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

B Nordic municipality size definitions

The size intervals and definitions by the statistical agencies in Denmark, Finland, Norway and Sweden.

Country	Size groups	Size metrics	Intervals
Denmark	(1) Rural municipalities (2) Hinterland municipality (3) Provincial city municipality (4) Metropolitan municipalities (5) Municipalities in the capital region	Population size in the largest city in the municipality	(1) 0–30 000 (2) 0–30 000 (3) 30 000–100 000 (4) 100 000– (5) NA (considers proximity to the capital)
		The number of workplaces	(1) 0–40 000 (2) 40 000–200 000 (3) 0–200 000 (4) 0–200 000 (5) 200 000–
Finland	(1) Rural municipalities (2) Medium urban municipalities (3) Urban municipalities	% of population living in urban settlements	(1) 160–90% of the population lives in urban settlements with a population size below 4000 (2) 60–90% of the population lives in urban settlements with a population size between 4000–15 000 (3) At least 90% of the population lives in urban settlements
		Urban settlement size	(1) The largest urban settlement has below 15 000 inhabitants (2) The largest urban settlement has between 4 000–15 000 inhabitants (3) The largest urban settlement is at least 15 000 inhabitants
Norway	(1) Small (2) Medium (3) Large	Population size	(1) 0–4 999 (2) 5 000–19 999 (3) 20 000–
		Bound costs of the municipality	(1) Low (2) medium (3) high
		Free disposable income of the municipality	(1) Low (2) medium (3) high
Sweden	(1) Small places and rural municipalities (2) Larger places and municipalities close to larger cities (3) Large cities and municipalities close to larger cities	Population size*	(1) 0–40 000 (2) 40 000–200 000 (3) 200 000–

*Sweden uses commuting-patterns to further categorize the municipalities in sub-dimensions within each category.

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