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Connecting People, Policy and Bicycles

A look at how digital technologies rewire the dynamics of public sector innovation in Copenhagen

Abstract

This study explores how digital technologies affect the dynamics of public sector innovation at city level. While existing research has extensively studied the effects of digitalization on markets and private sector innovation, empirical studies have remained scarce in a public governance context. However, a growing body of Smart City research has started to conceptualize how cities seek to develop data-driven solutions to today's most pressing policy challenges. Examining how the City of Copenhagen is trying to design a traffic data infrastructure for bicycles, this qualitative case study offers an empirical account of the underlying dynamics of data-driven public sector innovation. Based on a descriptive conceptual model, tentative propositions with regard to newly emerging practices, new actors, changing roles, and critical political dimensions are discussed. The findings suggest that digital technologies are driving increasingly flexible and collaborative forms of governance and a new market dynamic for citizen-centric data solutions. Finally, potential strategic implications for decision-makers in both public and private organizations are discussed.

Keywords

Public sector innovation, political innovation, collaborative governance, Smart City, city data infrastructure

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The fact that I handed in a Master thesis with the word ‘bicycle’ in its title may be of some surprise for my family. For years, my parents reliably retold the vivid story of me smashing my first bicycle as a frustrated little kid when trying to figure out how to cycle. I deeply thank my family, and my parents in particular, for having provided me with strong roots and the continuous encouragement to keep exploring new things and cutting my own path.

Finally, I would like to thank Tea who during the last months patiently endured countless reflections about actor networks and bicycle data. You make my life complete and I can’t wait to start our next chapter together.

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Glossary

Big data	High-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation (Gartner, n.d.).
Governance	As a broadly used concept, ‘governance’ generally refers to “all processes of governing, whether undertaken by a government, market or network” (Bevir, 2012). For this thesis, governance is understood as the processes that organize the management of innovation activities in the public sector.
Open data	Data that is openly published and freely available to everyone’s use.

"We don't have cyclists in Copenhagen, we merely have people who happen to ride their bicycles."

Quote from official report on urban bicycle life
(City of Copenhagen, 2013)

"What strange phenomena we find in a great city, all we need do is stroll about with our eyes open."

Charles Baudelaire

1. Introduction

1.1. Beyond technology: the 'Fourth Industrial Revolution'

The impact of digitalization extends beyond a mere technical shift toward increasingly interconnected means of production, service delivery and communication. In a hyper-connected world, the transition toward an 'Internet of Everything' connects not only things, but also people, processes and data at an unprecedented scale and scope (Bradley et al., 2013). In a 21st century running on different types of data, digital innovations not just become deeply interwoven into the economy – they also permeate into the very fabric of society. Forecasts indicating that the number of connected devices producing real-time data will jump from 6.3 billion in 2016 to more than 20 billion worldwide in 2020 (Gartner, 2015) add numbers to a development that rewires the *modus operandi* of governance, business and people's everyday lives. Trying to capture the magnitude of these change processes, Klaus Schwab, chairman of the World Economic Forum, referred to a "Fourth Industrial Revolution" which is "blurring the lines between the physical, digital, and biological spheres" (Schwab, 2015). Schwab concludes that adequate responses will require the collaborative efforts of "all stakeholders of the global polity, from the public and private sectors to academia and civil society." But how do such collaborative innovation efforts come into being? How can they be organized? And what political issues arise in such an interconnected, digital era in which traditional boundaries are fading and innovations need to reconcile the different interests and values that various actors bring to the table?

While commercial opportunities for ICT firms loom large in the form of a multi-trillion dollar market for interconnected devices and data infrastructures in the public sector alone (Accenture, 2015; McKinsey, 2014), the implications for public authorities seem more complex. A "tsunami of information" (Howard, 2015) from an ever-growing number of data sources offers new opportunities to understand citizens' needs as well as to design better public services. As these technology-induced dynamics coincide with urgent societal challenges such as climate change, the public sector is facing particularly high pressures to innovate (European Commission, 2017; OECD, 2016; World Bank, 2010).

These technological, societal, environmental, and political complexities become tangible at local city level. As nodal points of socio-economic development and continuing urbanization, cities around the world are pushing the digital agenda under the broad concept of 'Smart City' innovation. A growing number of collaborative initiatives substantiate the idea that cities have become frontrunners of new data-driven innovation practices (Smarticipate, 2016; Cosgrave et al., 2015; UN Habitat, 2016). Therefore, Smart City governance understood as the nexus of various efforts of different actors to shape a data-driven future emerges as a valuable object of analysis. Examining the dynamics within this newly forming realm of innovation can thus not only contribute to a better understanding of how digitalization rewires the practices of public sector innovation as such, but also help grasp the political dimensions of an interconnected world, in which innovation practice increasingly transcends the boundaries of disciplines, sectors, and responsibilities.

1.2. Copenhagen: becoming the world's first carbon-neutral capital through bicycle data innovation

The City of Copenhagen provides a particularly interesting case to study these phenomena. Heading the EU 28 Member Smart City Index (European Parliament, 2014), Copenhagen stands out among other municipalities with various Smart City initiatives targeted at improving the city's environmental performance and quality of life. To achieve the bold vision of becoming the world's first carbon-neutral capital by 2025 (City of Copenhagen, 2009), data-driven innovation in the design of public services enjoy a high sense of political urgency and commitment. With the Copenhagen Solutions Lab, a new governance body has been put in place in 2014 to accelerate Smart City development for a greener city: outside the traditional city department structures, actors from different sectors are brought together in various initiatives to develop and test innovative data solutions.

The opportunities and challenges regarding the public use of digital technologies in Copenhagen have become of growing interest for research (Giest, 2017). As a key focus area of the municipality's innovation efforts is traffic, the City's Technical and Environmental Department recently invested DKK 55 million in an Intelligent Traffic Management system, which allows to track and manage the city's traffic flows in real-time (City of Copenhagen, 2014). However, to reap its benefits, traffic experts within the department still need to solve another decisive challenge: while it is relatively easy to gather accurate real-time data of cars, buses and other motor vehicles, no technically and financially viable solution is available yet for bicycles. However, bicycles today already make up 36% of Copenhagen's traffic movements (City of Copenhagen, 2017). In 2016, for the first time, more bicycles made their way into the city center than cars (World Economic Forum, 2016). To achieve the ambitious climate targets, the share of bicycles in all commuter trips is intended to be further increased to 50% by 2025 (City of Copenhagen, 2017). Therefore, including big data on bicycles is crucial to obtain the full picture of the Copenhagen's traffic movements and to set the course for future infrastructure development.

The challenges to be solved are not only of technical nature. Another complicating factor is that cyclists typically exhibit a much more spontaneous and unpredictable (not to say 'anarchic') driving behavior. After unsuccessful attempts to solve the bicycle data puzzle internally, the traffic unit within the Technical and Environmental Department decided to reach out to external actors. Under the name 'Big Data Bicycle Challenge', a collaborative ideation workshop was hosted to develop and promote potential solutions together with ICT firms, startups, researchers, students, and representatives from other municipalities. Embedded into the context of previous and ongoing innovation initiatives, this challenge thus presents a valuable opportunity to explore the underlying mechanisms and issues of newly emerging public sector innovation practices.

1.3. Problematization

Research has intensively studied the transformative effects of digitalization on business models and innovation practice in the private sector. In a commercial context, concepts like open innovation (Chesbrough, 2006), crowdsourcing (Howe, 2008), and interactive models of diffusion (Akrich et al., 2002) are indicative of a wider paradigm shift toward more open and collaborative innovation practices. However, far less is known about how such ideas play out in the public sector. If the idea of "democratizing innovation" (Von Hippel, 2005) is taken seriously in a Smart City context (and the steady rise in more open and experimental practices in this field strongly suggests it should), then traditional practices of public sector innovation, power relations and modes of influence are increasingly called into question. What does this mean for city governance where commercial values and interests encounter many other public values? What key actors, concerns and processes are engaged in shaping the societal use of digital technologies? How do new forms of collaboration and the proliferation of new digital and physical devices not only change the dynamics in a market for public data infrastructures, but also the roles and responsibilities assumed by the actors involved in the process?

In a convoluted situation where digital technologies are disrupting the traditional ways of doing things, a closer look at how these dynamics translate into tangible initiatives at city level offers a promising starting point for an empirical investigation. The insights gathered could not only be useful for decision-makers in both private and public organizations strategically seeking to influence the direction of the ongoing reconfigurations. At a wider societal level, they can further contribute to highlighting the political dimensions of data-driven innovations, thereby adding relevance to a more informed discussion about potential normative guidelines for designing collectively desirable forms of collaboration across different spheres of society.

1.4. Purpose

The purpose of this thesis is to explore how digital technologies affect the dynamics of public sector innovation in a city governance context. Using selected Smart City initiatives in Copenhagen as an exemplary case of this broader issue, this inherently exploratory study is guided by the following research questions:

RQ1: What emerging practices characterize public sector innovation in a Smart City context?

RQ2: Who are the main actors engaged and what is their role in the process?

RQ3: What different values and concerns are at play and how do they give rise to political controversies?

RQ4: What are potential strategic implications for decision-makers in public and private organizations engaging in collaborative innovation efforts?

1.5. Expected contributions and delimitations

By investigating these research questions, it is hoped to contribute structured knowledge about the socio-technical effects of digitalization on public sector innovation. Prior research on Smart City innovation has largely focused on technological aspects, while remaining rather speculative regarding the implications for governance. Therefore, what is still missing is an integrated approach that explores how the organization of public innovation in an increasingly networked society (Castells, 2011) takes shape in practice. This thesis is an initial bottom-up attempt to fill this gap. Its findings can thus potentially add back to various academic fields, including the study of governance, market dynamics, and political sciences.

Forcibly, there are academic limitations in exploring such far-reaching and ill-structured phenomena. The objective of this thesis is not to reach monumental theoretical breakthroughs or universally applicable conceptual frameworks, as any claims to exhaustively capture the many interrelated issues and uncertainties involved in the topic in a single Master thesis are doomed to appear highly dubious. Instead, this study aims to provide a detailed description of the ongoing changes in public sector innovation in an exemplary setting. It is hoped that tentative but empirically grounded conclusions regarding the patterns and directions of these changes can inform future research on the socio-political dimensions of digitalization. However, despite these innate limitations in scope and generalizability, this study intends to develop useful insights regarding the problem at hand, not least by unraveling some of the inherent political issues and tying them to tangible practices.

2. Literature review: public sector innovation in the digital age

2.1. Open and collaborative: a new innovation paradigm

In response to an ubiquitous innovation imperative and technology-enabled possibilities to leverage diverse sources of knowledge, a new innovation paradigm emphasizing openness and collaboration emerged. Concepts like 'open innovation' (Chesbrough et al., 2006), 'user-driven innovation' (Von Hippel, 2005) and 'open collaborative innovation' (Baldwin & Von Hippel, 2011) describe a new logic that originated in private sector innovation theory. In essence, these concepts capture a shift from rather closed toward more open innovation models that allow organizations to leverage outside knowledge and ideas. Through a combination of outside-in and inside-out processes (Gassmann & Enkel, 2004), organizations disclose internal information in hopes that external actors can solve innovation challenges more effectively. Digital technologies play a key role in driving such new forms of co-creation: as access to information increasingly becomes a public good, the traditional roles of innovation users and providers can be turned upside down (Von Hippel, 2005). However, although collaborative arrangements have been found popular among firms trying to facilitate innovation in practice (Tether, 2002), the precise meaning and usefulness of 'openness' in innovation remains controversial in innovation research (Dahlander & Gann, 2010; Birkinshaw et al., 2011).

Nonetheless, the underlying principles of this approach have migrated into the public sector discourse. For instance, the European Commission has postulated 'Open Innovation 2.0' as a new public innovation paradigm to promote the "simultaneous value creation for civil society, business, academia, and government" (Curley & Salmelin, 2013:2). Public management scholars have similarly argued that in order to tackle today's complex policy challenges, the public sector should embrace radically new and collaborative ways of innovating (Bommert, 2010; Nambisan, 2008). However, as compared to commercial settings focused on product or process innovation, applying a similar logic in a public sector context raises a number of political issues as multiple interests, values and ethical considerations must be reconciled (Chandler, 2017; Perry & Wise, 1990). As Moore and Hartley (2008:18) point out, public innovations should be evaluated "not only in terms of efficiency and cost effectiveness, but also in terms of what might be considered right relationships in the society – some notion of justice and fairness." Although co-production in public service *delivery* is nothing entirely new (Whitaker, 1980), the idea of *co-creation* across all sectors indicates a profound reconfiguration of how public service innovation at the intersection of markets, public governance and technology is organized. Yet first empirical studies suggest that public bodies are still in the process of adopting open innovation and understanding the relevant issues (Lee et al., 2012). As a result, the literature examining collaborative innovation practices in the public sector has so far remained at its initial stages.

2.2. Shifting boundaries: governance in the digital age

While few empirical studies examine the concrete practices of open, collaborative innovation in the public sector (Mergel & Desouza, 2013), public management scholars have addressed more broadly how governance is changing in the face of growing societal and technological complexity. Osborne (2006) argues that a growing demand for new ways of thinking and organizing the public sector contributes to a historical shift: while traditional approaches to public administration in a Weberian sense have focused on improving the efficiency of internal bureaucratic processes, more recent forms of public governance increasingly focus on innovating inter-organizational processes and outcomes. This outward-orientation differs from primarily market-driven approaches such as New Public Management, which is mainly concerned with optimizing the cost-benefit ratio of public services (Hood, 1991). Other authors have addressed the impact of technology in driving these developments. For instance, the notion of 'Digital Era Governance' (Dunleavy et al., 2006) seeks to capture how governance practice is increasingly driven by IT-centered change processes and innovation needs. Similarly, Hartley (2005) introduced the term 'Networked Governance' to describe the increasing importance of hybrid partnerships and interactive networks in solving today's policy challenges. Conceptually in its perhaps most extreme form, O'Reilly (2010) argues for the need to rethink governments as interactive platform, modeled after the success principles of computer platforms. As a whole, there seems to be consensus that it becomes increasingly harder to distinguish between the roles and boundaries of different sectors (McGuire, 2006) and that there is a growing need to examine how collaborative governance practices can be designed effectively (Sørensen & Torfing, 2011; Ansell & Gash, 2008).

How do digital technologies affect governance relationships? Chun et al. (2010) propose 'Government 2.0' as a catchphrase for more open governance modes based on the principles of participation, transparency, and collaboration. For Bertot et al. (2010), this trend is fueled by the proliferation of big data and digital communication habits, which contribute to a cultural shift toward heightened citizen expectations regarding government transparency and responsiveness. Some studies have thus examined the citizen-empowering impact of publicly disclosing government data using digital technologies to enable new forms of engagement (Maier-Rabler & Huber, 2012; Janssen et al., 2012; Linders, 2012; Loader & Mercea, 2011). Others find the role of citizens to evolve into an active source of public innovation (Schmidthuber & Hilgers, 2017; Nam, 2011, Hilgers & Ihl, 2010).

However, while these studies are indicative of the many ways in which digital technologies have started to extend and blur the boundaries of governance, they seldom go beyond the dyadic relation between governments and citizens. Thus, the active role of market actors in changing governance practice is often sidelined, while technology is mostly understood as a mere technical means to improve existing public services and processes. Therefore, what remains an under-researched field is how technological innovations such as the generation and use of big data and interconnected devices in itself give rise to entirely

new governance challenges and, in turn, how new governance and innovation practices might drive such technological inventions.

2.3. Smart Cities as magnifying glasses of socio-technical change

A closer look at the Smart City literature allows to identify city governance as a both conceptual and spatial magnifying glass of the previously mentioned changes regarding more open forms of innovation and data-driven governance. Although the term 'Smart City' remains an ambiguous and often ill-defined concept (Hollands, 2008; Albino et al., 2015), most definitions holistically encompass the overlapping boundaries of technological, institutional, and human factors (Nam & Pardo, 2011). Nicely balancing the inherent technological, economic, social and political dimensions, Schaffers et al. (2011:432) define cities as 'smart' "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and high quality of life with a wise management of natural resources, through participatory government." Other authors have specifically addressed the central role of open innovation in realizing the idea of smarter cities. According to Paskaleva (2011:166), "open innovation in smart cities means using ICT for delivering more sustainable and inclusive cities with better quality of life for their citizens through delivering better services and goods in a mutual and creative relationship between local officials, professionals, and the people, supported by the right set of strategic policies." Regarding the impact of technology, some researchers have started to problematize the political consequences: As digital devices and infrastructure produce vast amounts of big data, new governance modes are needed to design and manage the real-time analysis of city life (Kitchin, 2014). Collaborations across sectors further raise issues regarding the influence of private companies needed for the technical realization of these ambitions (Söderström et al., 2014). Additional governance challenges arise as Smart City innovations require the involvement of citizens to gather data (Degbelo et al., 2016).

What matters most for the purpose of this thesis is that such Smart City innovation initiatives offer a tangible unit of analysis for empirically tracing how this changing interplay of different actors, logics, concepts and technologies plays out in practice (Alawadhi et al., 2011; Bakici, 2013). Similar considerations have inspired previous attempts to develop a more integrative approach to studying the complex interrelations built into Smart City innovation. For instance, Chourabi et al. (2012) suggest to not only focus on the immediate dimensions related to technology, organization and policy-making, but also on the wider contextual factors such as the economy, local communities, and environmental infrastructures that affect governance systems (see Figure 1). Following this holistic view, this thesis can partly be seen as an attempt to add empirical substance to such tentative frameworks by capturing the actual practices and dynamics that tie these dimensions together.

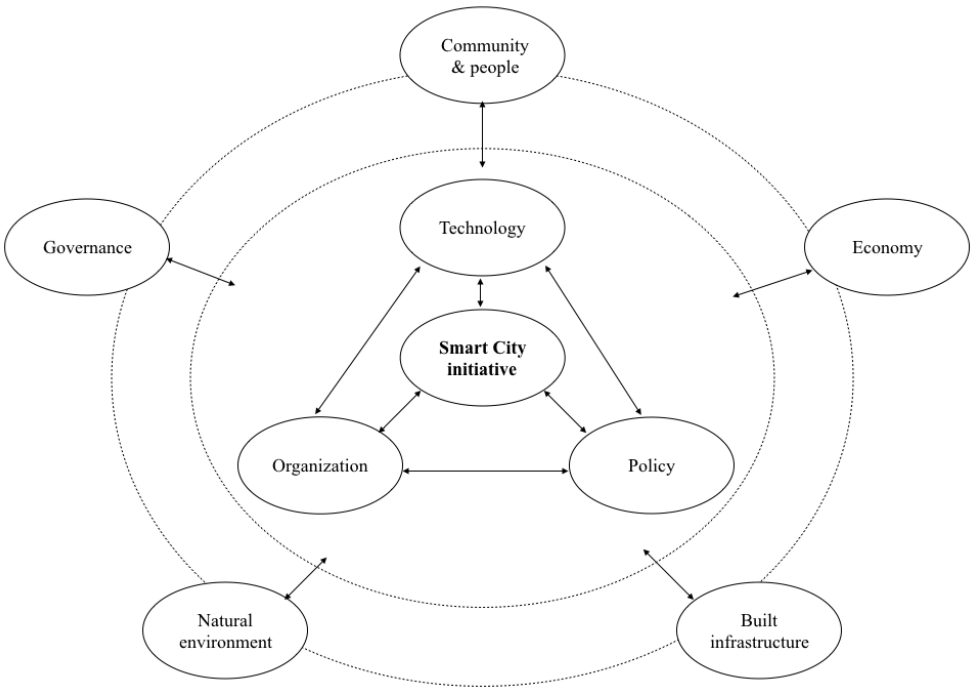

Figure 1. Existing conceptual framework offering a starting point for understanding and studying Smart City initiatives (adapted from Chourabi et al., 2012)

2.4. Political dimensions of public sector innovation

Up to this point already, the literature review has touched upon several political dimensions of changing public sector innovation dynamics in a digitalized world: (1) the multiplicity of economic and public values which potentially compete in collaborative initiatives; (2) the altered relations and distribution of roles between citizens, firms and public authorities in more collaborative forms of governance; and (3) the role and influence of individual actors in shaping data-driven public innovations. A few additional contributions are worth mentioning to clarify the potential for political controversy addressed by this thesis.

Combining the viewpoint of political sociology with an anthropology of technology, Andrew Barry has illuminated the evolving link between technology and governance in what he calls a "technological society". For Barry, "the conduct of politics today is a technical matter. Technical innovation has become part of political life." (Barry, 2001:10). Central to this thinking is the distinction between 'politics', which denotes a set of technical practices and institutions, and the 'political', which designates a space of deliberation and potential disagreement between different actors (Barry, 2002). This provides a more nuanced account of what is meant when we speak of new forms of 'governance' that emerge in response to technological innovations. Smart City innovations can thus be viewed not only as the center stage of new ways to organize markets and politics, but also as spaces of political contestation where different actors negotiate the terms, uses and directions of technological innovations.

In the words of Barry (2001:10), it follows that "[...] to analyze the conduct of political and economic life without considering the importance of material and immaterial devices and artefacts is simply to miss half the picture." This takes the idea that technical artefacts have *politics* (Winner, 1980) further: digital innovations and data also entail new forms of *political controversy* "as they may cut across and undermine the boundaries of existing social and administrative arrangements" (Barry, 2001:19).

These considerations invoke even more profound questions regarding the potentially changing nature of the public sphere as such, which have traditionally been debated within the realm of political philosophy. For instance, Hannah Arendt's participatory conception of citizenship (Arendt, 1998 [1958]) puts emphasis on the spatial quality of the public sphere as a public space that organizes how citizens come together, debate differences, and search for a collective solution to their problems (D'Entreves, 2016). Viewing emerging public innovation practices as precisely such spaces that bring not only citizens but also a wide range of other interest groups together, it becomes clearer why digitalization might give rise to both new forms of political agency and new matters of political concern. The political struggles for what a collectively desirable Smart City might be would thus open a new space of "subpolitics" (Beck, 2015) that in the guise of collaborative innovation take place outside traditional modes of democratic deliberation. While this must not necessarily confirm the Habermasian critique of the contemporary public sphere as being dominated by the secret politics of powerful interest groups (Habermas, 1989 [1962]), it still seems inevitable to keep the possibility of such power imbalances in mind throughout any analyses.

2.5. Synthesis and literature gap

Drawing selectively from and across different academic disciplines, the literature review has collated existing contributions that allow to identify a starting point for further empirical investigation. First, although political science and public management scholars have addressed the emergence of a new collaborative approach to innovation that originated in the market sphere, analyses of how such opening processes play out in a public sector context so far have mostly remained on a conceptual level. Second, it was shown how several authors have started to examine how digital technologies are blurring the traditional boundaries of governance, while often somewhat narrowly focusing on the altered relations between citizens and public authorities. Third, a look at the more recent Smart City literature has allowed to identify city governance as a uniquely suited unit of empirical analysis where many of the interrelated issues at hand coincide (see Figure 2). Fourth, the political relevance of examining the role of digital technologies in shaping new ways of organizing technological innovations in a public sector context was clarified, as they may create new spaces for political controversy, strategic influence and the exercise of power.

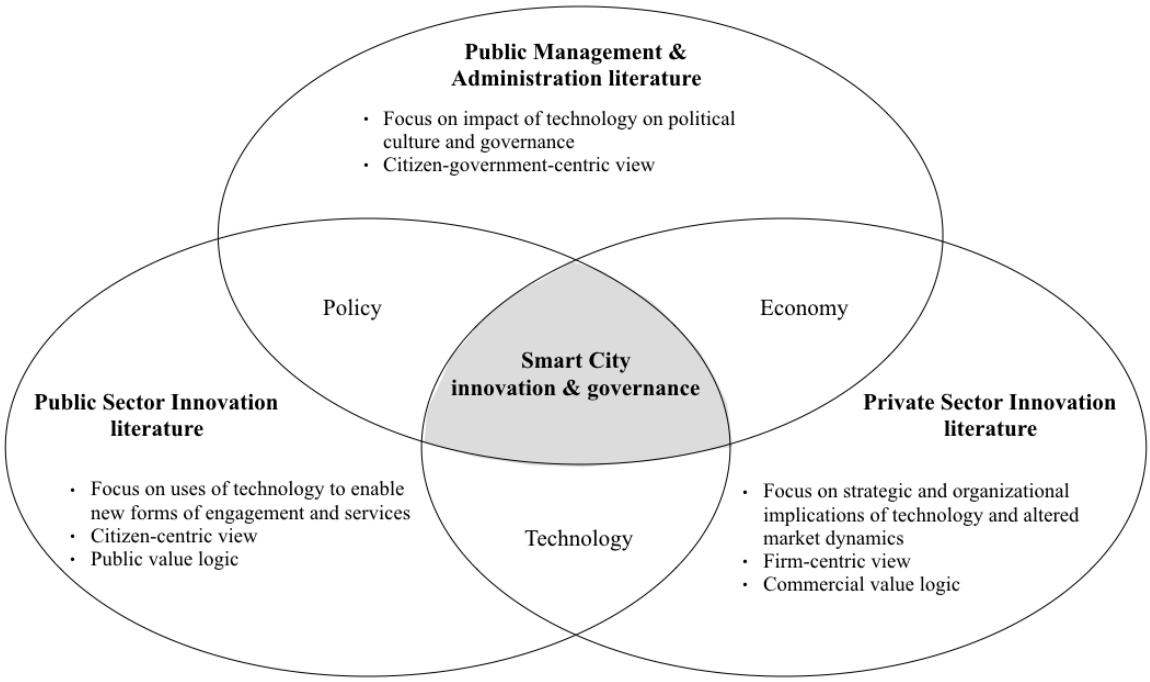

Figure 2. Smart City innovation and governance as suitable unit of analysis for studying socio-technical change and illuminating emerging practices of public sector innovation

In sum, it is clear that research has partly recognized the fundamental ways in which digitalization disrupts traditional boundaries of governance and public sector innovation. However, existing accounts have remained either within individual academic disciplines or confined to individual aspects of these interrelated changes. This implies that a literature gap exists not only in terms of drawing these different threads together. In addition, a knowledge gap exists regarding the concrete practices that shape the ongoing changes throughout society, governance, and markets. Taking the interdisciplinary perspective of a growing body of Smart City research as a starting point, an exemplary empirical account of the underlying interactions, interests, technical devices and concerns involved in current cross-sector innovation initiatives can thus help advance the practical and theoretical understanding of the phenomenon at hand.

3. Theoretical lens for studying data-driven innovation dynamics

The inherent complexity of Smart City innovation comes with significant challenges regarding a meaningful and systematic empirical investigation. What theoretical scaffolding can suitably support and guide a study seeking to capture how digital technologies create new ways to organize the relations between governance, markets and society? This section outlines how selected contributions from science and technology studies (STS), organization studies and practice theory can help refine the initial theoretical understanding of the phenomenon at hand and provide direction for subsequent empirical investigations.

3.1. Smart City innovation as socio-technical arrangement in the making

The literature review suggests that studying today's highly interconnected forms of socio-technical change requires a rather holistic and systemic approach. The necessity to study technological innovations not in isolation, but in connection with the wider societal context in which they take place has been pointed out aptly by Barry (2001:211):

> *"[...] Just because an object or device is new does not make it an invention. What is inventive is not the novelty of artefacts and devices in themselves, but the novelty of the arrangements with other objects and activities within which artefacts and instruments are situated, and might be situated in the future."*

The concept of such 'socio-technical arrangements' that span across different boundaries and spheres is similarly proposed by STS scholars. Analyzing the ongoing controversy regarding the creation of carbon markets, Callon (2009) argues that the functioning of markets critically depends on the socio-technical arrangements of which they are made. According to Callon, the design of such arrangements not only becomes a strategic activity for a variety of actors, but also takes on the form of collective ongoing experiments which contribute to "redefining relations between science, politics and economics, and to raising the question of the mechanisms through which boundaries are drawn between these different worlds." (Callon, 2009:2).

With regard to the underlying mechanisms of such boundary dynamics, Callon's own work on 'framing' and 'overflows' offers valuable insights (Callon, 1998). Broadly speaking, Callon argues that on the one hand, interactions between different actors throughout the economy require a *frame* that makes actions calculable and sufficiently defines what could be called 'the rules of the game'. On the other hand, such frames are regularly disrupted by what Callon calls *overflows.* Today more than ever, new scientific knowledge or technological innovations can subject an existing frame to a fundamental re-evaluation. In such states of extensive controversy in which the traditional way of seeing or doing things is called into question, Callon speaks of 'hot situations'. In order to in turn reestablish an adjusted and temporarily stable frame, investments in metrological devices to make sense of the new circumstances play a key role. At core of this dynamic thus lies a continuous dialectic between stabilizing framing and disruptive overflowing dynamics as well as the efforts of

different actors competing to realize their respective "descriptions of future world states" (Callon, 1998:260).

Equipped with this conceptual and terminological vocabulary, what does it mean to speak of socio-technical arrangements in the context of Smart City innovation? Viewing changes in public sector innovation as changes occurring within a socio-technical arrangement 'in the making' offers three advantages: First, it allows for an integrated account of the active role of new technical devices on the one hand, and the web of relations with and between different societal actors in which these technological innovations are embedded on the other. In this sense, adopting the notion of dynamic arrangements – or *agencements* (Callon, 2007) – in which socio-technical change takes shape is a promising first step to overcome conceptual separations in studying changes in technology, politics, the economy, and society. Second, a focus on how such arrangements are organized increases awareness about the centrality of intermediaries and interactions in both holding the overall arrangement together and determining its shape. When studying frameworks for collaborative innovation, this implies the need to pay careful attention to the various links between organizations, individuals and technical devices that together add up to a socio-technical arrangement. Third, applying the logic of 'hot situations' to the changing dynamics of public sector innovation renders the political controversies inherent to newly emerging forms of collaboration conceptually tangible: as digital technologies and increased pressures to innovate are increasingly calling previous frames of public innovation practice into question, multiple actors can be assumed to strategically advocate their interests to realize their respective visions and conceptions of future Smart City development.

3.2. Tracing the links: actor network theory vs. action nets

If conceptualizing newly forming innovation practices as socio-technical arrangements in the making is the starting point, the question remains as to how such dynamics can be usefully studied. Two particular challenges seem apparent: First, how can we understand the concrete links between the various actors while taking into account technical, human, and organizational dimensions? And second, how can we describe and trace the ongoing processes and controversies shaping the arrangement in a systematic and coherent way?

3.2.1. Actor network theory

In many regards, the theoretical underpinnings of actor network theory (ANT) can offer valuable guidance. Originally conceived by Bruno Latour and Michel Callon to incorporate the material dimensions of science and technology into social theory (Callon & Latour, 1981), it is less a comprehensive theory, but rather a "travel guide" for tracing the various associations that may exist between actors (Latour, 2005). The logic and terminology of ANT does not come without challenges. In fact, using Latour's own words, ANT comes with "[...] a name that is so awkward, so confusing, so meaningless that it deserves to be kept." (Latour, 2005:2). However, it might precisely be the theory's inherent ambiguity that

makes it a powerful analytical tool to explore the complex and interactive dynamics that exist in today's reality of urban governance (Bender & Farias, 2010). For the purpose of this thesis, two main elements of ANT seem particularly useful: First, a network definition of what is an 'actor' that specifies the agency of both humans and non-human devices. Second, the concept of 'translations' as processes through which the identity of actors and the possibilities for interaction are constantly negotiated and delimited (Latour, 1984; Callon, 1990).

Actors as networks

Studying the interplay of different actors in public sector innovations first requires defining what is meant by the term 'actor'. ANT metaphorically regards actors as in fact being 'actor-networks' that are essentially made up of a dense web of relations. It is a core principle of ANT that it rejects categorical preclusions regarding what can obtain the status of an actor. In Callon's words, "an 'actor' is any entity able to associate texts, humans, non-humans and money." (Callon, 1990:140). The agency of an actor manifests itself when "[...] actors might be associated in such a way that they make others do things." (Latour, 2005:107). This combination of agnosticism, generalized symmetry, and free association (Callon, 1986) broadens the scope of analysis, as it includes the potential agency of technical devices involved in Smart City innovation practice. An ANT perspective thus suggests to not only look at how technologies enable new connections between people and organizations as passive intermediaries, but also at the ways in which they themselves might constitute new actors that actively alter the roles and identities within socio-technical arrangements.

Connections as translations

If an actor is seen as a network of various relationships and if the goal is to explore the interactions across these ties, the question is how such connections come into being in the first place. Within ANT, processes of translation provide this conceptual link. As conceived by Latour (1984), the translation model regards the capacity to act not as something initially possessed and then diffused by an actor, but as something that emerges from the multiple associations in which an actor is embedded. Passing through different moments of translation, the ideas and concerns of different actors are taken up and passed on by others, thereby being continuously modified (Callon, 1986). In turn, the eventual organization of socio-technical networks for interaction is the outcome of collective negotiations and choices made by different actors (Akrich et al., 2002). Therefore, when exploring the dynamic character of organizing innovation through the lens of ANT, such translation processes as the mechanisms behind interactions and relations become critical objects of analysis (Law, 1992). Given that Smart City innovations may entail different views, interests and understandings, heightened sensitivity to how ideas and concepts related to technological innovations are translated by and between different actors becomes crucial.

3.2.2. Problematic assumptions

These key concepts being clarified, how far can ANT take the exploration of newly forming socio-technical arrangements? On the one hand, ANT seems to presents a powerful analytical toolkit to cut across spheres and domains and to direct the focus on the inherent heterogeneity of socio-technical arrangements (Latour, 1996). Specifically in the context of the Smart City debate, the critical analysis of the strategic positioning of large ICT firms by Söderström et al. (2014) has shown that ANT can be usefully applied in tracing the identities and actions *of one particular actor* from the beginning of a controversy to a more or less stabilized outcome: after having created a demand for smart technologies among public authorities through extensive marketing, specialized companies have successfully established themselves as obligatory passage points not only in implementing, but also in actively shaping the Smart City agenda. ANT thus allows to systematically retrace in retrospect how actors strategically seek to shape emerging socio-technical arrangements according to their interests. On the other hand, however, what if Smart City initiatives *as a whole* today might still resemble rather 'hot' arrangements in the making than readily stabilized actor-networks? Rather than assuming to be able to describe an initiative's current shape from a single actor's perspective in retrospect, it seems important to focus on identifying the crucial actors in the first place, as well as the ongoing practices and competing interests that might influence the organization of public sector innovation in the future.

3.2.3. Action nets as a useful alteration

From the perspective of an organization scholar, Barbara Czarniawska has made a similar argument: while, according to her, ANT is helpful to study the eventual *organization* of interaction in novel arrangements after controversy, it is more difficult to capture their formation in earlier stages where identities and interactions might not yet be clearly established (Czarniawska, 2004). To also capture the more fragile and temporary processes of *organizing* (Weick, 1979), Czarniawska's concept of 'action nets' presents itself as a suitable alteration of ANT for the purpose of this thesis. For Czarniawska, the central idea behind action nets is to offer "a compromise devised to embrace both the anti-essentialist aspect of all organizing (organizing never stops) and its apparently solid effects (for a moment things seem unchangeable and 'organized for good')" (Czarniawska, 2004:780). While the study of action nets also builds on the concept of translation, it takes a different approach regarding time: While the logic of actor-networks presupposes the sequential existence of first actors, then networks, and finally actions within a network, an action net perspective reversely starts with identifying actions (Lindberg & Czarniawska, 2006). An actor is thus the product of organizing processes, not the source. Stable networks may then arise in a final step or not.

By taking actions as the focal points of analysis, this approach offers decisive advantages for studying the issue at hand as it avoids treating newly forming organizing processes of Smart City innovations as already stabilized actor-networks. Therefore, the notion of changing action nets provides complements ANT in a way that allows to study socio-technical arrangements from the ground up without too many previous assumptions.

3.3. A focus on 'proto-practices'

As Czarniawska points out, the concept of action nets has no analytical ambitions beyond minimizing assumptions prior to the analysis (Czarniawska, 2004:780). Thus, if the empirical investigation of action nets implies focusing on actions, it remains to be clarified what exactly is meant by 'action'. In the following, it is argued that practice theory can usefully complement the concept of action nets by establishing newly emerging and contentious practices as tangible units of analysis.

The term 'practice theory' denotes a diverse set of theories that, broadly speaking, seek to theorize how social actors shape their surrounding environment. A common denominator among the different strands is the proposition that such action is made possible through commonly shared 'practices' (Echeverri & Skalen, 2011; Bourdieu, 1977; Giddens, 1984). Reckwitz (2002:249) defines 'practice' as "a routinized type of behavior which consists of several elements, interconnected to one another [...]". For Reckwitz, these elements not only include bodily and mental activities, but also material things and their use. For this thesis, this has important methodological implications: First, observable interactional practices emerge as the smallest unit of empirically grounded social analysis and thus also for studying the interactions between different actors (Reckwitz, 2002:249). Second, studying practices also entails accounting for social meanings and thus not only how artefacts are used in particular ways, but also how they are described and understood by different actors (Reckwitz, 2002:250).

Focusing on how new practices come into being, Shove and Pantzar (2005) have studied the emergence of Nordic Walking practices. Their findings suggest that new practices emerge through an interactive co-creation process in which multiple actors seek to integrate new competences, images and devices. Similar to Callon's concept of 'hot situations', such emerging 'proto-practices' establish new links between actors and artefacts that call previous links and ways of doing things into question. Although Nordic Walking sticks are rather not a child of the digital age, this idea of newly emerging 'proto-practices' comes full circle with the starting point of this thesis; namely the suspicion that the proliferation of new digital devices might be disrupting routinized practices and role distributions in public sector innovation.

3.4. Synthesis

Based on the literature review, this thesis has started from the basic presumption that digital technologies alter how publicly and socially relevant innovation processes are organized across various sectors of society. In a next step, a possible theoretical understanding of these interrelated changes at a local city level has been developed: viewing Smart City innovation as dynamic socio-technical arrangement allowed to gain an idea not only of how technological and societal changes relate to each other, but also of how such ongoing changes might be driven by the strategic efforts of various actors in states of 'hot' controversy. Building on this conceptual understanding, a theoretical lens has been derived through which such changes can be empirically studied. First, in specifying that socio-

technical arrangements are essentially made up of various human and non-human actor-networks that are linked through continuous translation processes, ANT provided a technical vocabulary for an explorative study. Second, arguments taken from the concept of action nets and practice theory allowed to identify emerging practices and their entanglements with new technological artefacts as suitable starting point for analyzing the ongoing dynamics within socio-technical arrangements.

Clearly, this theoretical standpoint comes with a few implicit assumptions. Rather than presenting a tight theoretical framework from the outset, this thesis assumes that an explorative study equipped with a basic conceptual understanding and a primarily technical literature (Strauss & Corbin, 1990a) may offer decisive advantages in studying new and evolving phenomena. Although the presented theory has helped specify an ontological basis by establishing practices, actors and controversies as potentially important variables of analysis, this study initially sets out with no further preconceptions about the specific relationships among these variables (Eisenhardt, 1989). Deliberately beginning the investigation with a rather clean slate is intended to leave room to discover new aspects of the phenomenon. This approach follows Czarniawska (2004:784) suggestion to investigate action nets with no more than two questions in mind: “What is being done? And how does this connect to other things that are being done in the same context?” Similarly, Latour (2005) encourages researchers using ANT to leave the idea of a possibly restrictive framework behind and instead aim for an open-ended description of the mechanisms behind new topics.

4. Methodology

Attempting to investigate emerging phenomena in the broad field of public sector innovation, this study deliberately combines an exploratory research approach with an exemplary case study. To outline the research process, this section pays considerable attention to explaining and describing the methodological choices made.

4.1. Research approach

As outlined before, open and collaborative forms of governance and innovation are young concepts in public management and Smart City research. Aiming for an open-ended inquiry, this study took a qualitative case study approach based on the analysis of official documents, participant observations, and in-depth interviews. To offer an empirically grounded and descriptive account of how digital technologies both demand and enable new forms of governance, the approach was geared toward developing suggestive insights about new relations and practices, which can lay the ground for future and more broad-based work (Edmonson & McManus, 2007). The principle advantage of qualitative research when exploring phenomena characterized by rapid social change is the ability to go beyond testing existing models and scientific knowledge to identify emerging or entirely new practices (Flick, 2009). Following Eisenhardt (1989), a case study approach was found suitable to break down a complex issue into more focused units of analysis that can be studied alongside concrete empirical examples.

As outlined before, the study initially departs from a preliminary conceptual understanding regarding the potential transformative effects of digital technologies. In subsequently moving back and forth between newly collected data and this guiding theoretical framework, the study follows an abductive logic. In the words of Dubois and Gadde (2002), this iterative process of 'systematic combining' allowed theory, empirical fieldwork and case analysis to evolve simultaneously. This means that the theoretical understanding and the case were continuously refined as data was collected and analyzed, while in turn directing the collection of additional data.

4.2. Study design

The study centers on a single core case: the City of Copenhagen's approach to Smart City innovation, with a particular focus on the currently ongoing efforts to develop a real-time data infrastructure for bicycles. The following sections motivate the choice of this particular case and outline the case building process.

4.2.1. Case selection

Given the global nature of the phenomena under investigation, the critical reader might wonder: why Copenhagen? As the purpose of this study was to develop theoretical knowledge rather than to test it, the key challenge was to identify a particularly rich and representative case regarding novel developments in public sector innovation. Eisenhardt and Graebner (2007:27) suggest that theoretical sampling is a suitable strategy "for illuminating and extending relationships and logic among constructs". Yin (2014) similarly argues that a single case should be chosen depending on to what extent it can provide revelatory insights, extreme examples, and unique opportunities for access. Following this logic, the choice for the purpose of this study was informed by the following criteria: First, potential cities had to have a large-scale and credibly recognized Smart City development agenda in place, ideally including clearly specified targets and measures. Second, to analyze effects on governance, there ideally had to be adjusted institutional arrangements in place to facilitate innovation efforts. Third, these efforts needed to be ongoing for some time to allow for an analysis of developments and experiences in retrospect over a longer period of time. Finally, given this research project's limited available time and resources, the case needed to offer the opportunity to draw out a specific technology-oriented innovation challenge offering a chance to illustrate the dynamics of collaborative innovation and potential underlying controversies in a concentrated way. Based on these criteria, an online pre-study examining research reports, governmental documents, and media articles allowed to identify the City of Copenhagen as a suitable case example (see Appendix 3 for an overview).

4.2.2. Multiple methods

As suggested by Bryman and Bell (2011:397), a strengthened triangulation of evidence was made possible by using multiple methods and sources of data, allowing to grasp the phenomenon from different reference points. Figure 3 provides an illustration of the layered research design. While reviewing existing literature in response to upcoming concepts during the empirical data collection took place throughout the whole process, the observations and interviews have been deployed sequentially. First, a preliminary expert interview and analyses of official documents provided an understanding of the specific context of the case and allowed to identify suitable opportunities for first observations. Following a full-day participant observation of a collaborative innovation challenge, in-depth interviews with key participants were conducted to understand observations in more detail and to draw out the key issues within the core case.

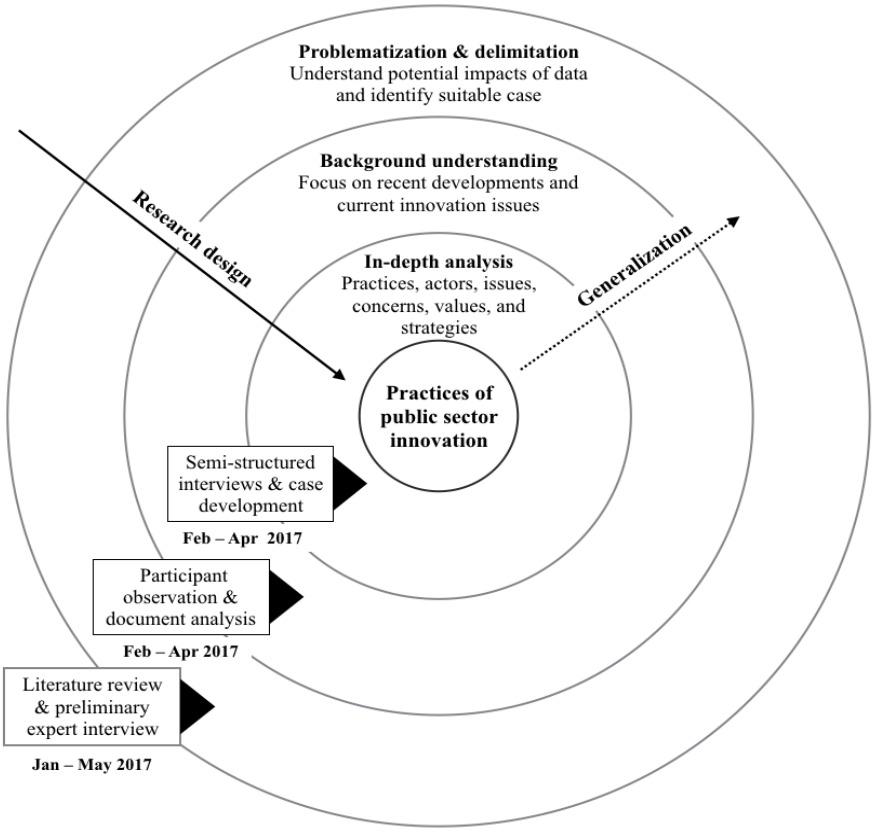

Figure 3. Illustration of the layered research design

4.3. Data collection

The empirical evidence gathered by this study stems from two primary sources: a participant observation during an open innovation event and subsequently conducted semi-structured interviews with participants who represented critical actors within the innovation challenge. In addition, secondary sources such as official documents and websites were analyzed to provide complementary background information on the context, inform the interview content and enrich the overall case. In the following, the data collection processes and methods are explained.

4.3.1. Exploratory pre-study

An initial exploratory examination of recent reports on public innovation and Smart City development published by international organizations, research institutes, private organizations and EU government bodies allowed to identify potential cases for analysis. In combination with reviewing recent newspaper articles, this also allowed to identify current controversies, trends and key issues in Smart City innovation. After having identified Copenhagen as a potentially suitable case across these sources, an in-depth interview with Frans La Cour, one of the city's data and Smart City specialists allowed to identify current innovation challenges and to gain access to an innovation workshop hosted by the municipality.

4.3.2. Participant observation and conversational interviews

On February 20, 2017, I attended a full day workshop in Copenhagen hosted by the City's Technical and Environmental Department. The event aimed at solving one of the administration's most pressing technological innovation challenges through a collaborative ideation day, bringing together 53 representatives from the private sector, academia, civil society organizations, and other municipalities. As Kawulich (2005), referring to Schmuck (1997), has pointed out, observations enable researchers to identify who interacts with whom and what issues are prioritized. Participant observation was therefore chosen both as a data collection method and analytical tool to capture the interactions and controversies between different actors involved in the innovation process. Moreover, first-hand observations were chosen to develop an initial understanding of the significance and meaning of different issues for participants (Evans, 2012). Following DeWalt and DeWalt (2011), the intention was therefore not only to enhance the quality of the study's data, but also the quality of the interpretation of the data gathered in later stages.

When conducting participant observations, researchers can be involved to varying degrees. Applying the classification of Gold (1958), I assumed the rather passive stance of an 'observer-as-participant': focusing on listening and detailed observations, I refrained from active participation in the event. However, during the interactive phases of the workshop, I approached 12 participants in short conversational interviews of between 10-15 minutes each. The questions asked were open, focusing on the participant's background, motivations to attend the workshop, and main impressions. The eventual data gathered took the form of extensive field notes of ten hours of observations, including the short interviews. Observations were noted down sequentially in addition to my own mental reflections and impressions. To minimize potential subjective researcher bias (DeWalt & DeWalt, 2011), personal comments and impressions were marked visibly. Abbreviated manual notes were transcribed digitally within 24 hours after the observations.

Finally, the use of participant observations entails significant ethical considerations. Most important, Kawulich (2005) emphasizes the ethical obligation to let the community being studied know about one's role and intentions as a researcher. Therefore, the organizers were informed about the research purpose of my attendance prior to the workshop. During the conversations with participants, I introduced myself as a student and briefly explained my research project and motivation to attend the event. Finally, information gathered from conversational interviews during the event was anonymized.

4.3.3. Semi-structured interviews

Nine purposively sampled semi-structured interviews (Bryman & Bell, 2011:492) with both organizers and participants of the workshop were carried out to deepen and validate the tacit understanding about the actors' concerns and interactions gathered during the participant observation. Semi-structured interviews were chosen as a particularly useful method to explore how interviewees frame and understand relevant issues and what they consider important (Bryman & Bell, 2011:495). Interviewees were sampled based on their

involvement in the workshop, their overall innovation efforts of the municipality, and their perceived potential to illuminate the research questions. A detailed list of all interviewees, their organizations and positions can be found in Appendix 1. Particular efforts were made to capture the views of different actors and organizational types. A stronger representation of the municipality's administration (four interviews) resulted from the need to explore the previous experiences and challenges of the public sector in greater detail, assuming different views depending on the respective department and role. However, the sample composition also reflects a lower willingness of many company representatives to agree to be interviewed on collaborative innovation initiatives and the fact that systematic collaborations with academic institutions turned out to be less frequent in Copenhagen's approach to Smart City innovation than with private companies. Following the reasoning of Strauss and Corbin (1990b:212), samples were added within these practical constraints until theoretical saturation was achieved in terms of no additional major issues emerging, well-developed thematic categories and the possibility to establish empirically validated relations between the key categories.

Throughout the interviews, an interview guide was used (see Appendix 2). Questions were formulated to cover pre-defined topics, but kept rather open to enable a flexible interview process (Kvale, 2008). Additionally, some questions and focus areas were adjusted to the interviewee's professional background beforehand based on information available online via LinkedIn and websites. After warm-up questions aimed at an unconstrained atmosphere, interviewees were invited to share detailed descriptions of their organization's role in the innovation process, motivations to engage in collaborations, past experiences, particular challenges and concerns, as well as their views on the role of digital technologies in public innovation projects. During what Rubin and Rubin (2005) call 'responsive interviewing', follow-up questions were used to guide the interviewee toward more detailed discussions of relevant aspects. In some occasions, new questions and topics emerged throughout the interview, which required an ad-hoc adaptation of the guide.

Interviews lasted between 32 and 75 minutes and were conducted via phone or Skype. Conducting interviews via phone is often criticized as it may allow for less time to build a trustful relationship (e.g. Rubin and Rubin, 2005). However, in the case of this study, most interviews built on previous face-to-face interaction during the workshop, allowing for initial ice-breakers and specific questions based on a commonly shared experience. Nevertheless, a key challenge remained to encourage interviewees to also openly discuss issues that are potentially politically or commercially sensitive. Therefore, interviews were not taped, but codified by abridged notes that were transcribed immediately after the end of the interview. To increase the reliability of the data, the transcripts were subsequently emailed to the interviewee for verification and approval.

4.4. Data analysis

Reflecting the abductive research approach taken by this study, the logic applied for data analysis has roots in grounded theory (Glaser and Strauss, 1967). Drawing on Strauss and Corbin (1990a), the coding of field notes and interview transcripts unfolded in three main stages: First, data was examined, compared, and broken down into apparent basic issues. Second, it was examined how these issues relate to each other and what further issues might emerge from these interconnections. This step involved contrasting the findings against the four guiding research questions. Third, core categories were prioritized around which other issues could be organized in a conceptually coherent and theoretically parsimonious way. These stages were iteratively applied throughout the data collection process. Lastly, the scope of the case was successively reduced throughout these steps to focus the findings on the objectives of the study. This means that such findings were suppressed that seemed interesting, but could not be directly related to one of the research questions or to a concrete example within the case.

Bazeley (2013) argues that identifying such core categories can at best be an intermediary process between coding and theory development. To move beyond what Bazeley criticizes as "descriptive reporting with a few illustrative quotes [that] is likely to be unconvincing" (Bazeley 2013:191), the findings within the categories were organized to form an argument that supports subsequent theoretical conclusions. The result is what Strauss and Corbin (1990b) call a 'storyline' that frames this study's empirical account of the interrelated dynamics in Smart City innovation and governance in a contextualized and integrated way.

4.5. Quality

Some additional considerations have guided the research process regarding its quality. Due to the explorative nature of the study, traditional positivist evaluation criteria based on validity and reliability concerns were considered less applicable. Drawing instead on the idea of trustworthiness as the overall goal of qualitative research (Lincoln & Guba, 1986), the following section addresses additional measures taken to enhance the study's credibility (4.5.1) and transferability (4.5.2).

4.5.1. Credibility

According to Merriam (1988), a qualitative study is credible if the findings are congruent with reality. Flick (1990) critically argues that the use of illustrative quotations and observations alone is not sufficient to meet high credibility standards. Therefore, as suggested by Mishler (1990), this study aimed to weave empirical data into an evolving case narrative, thereby offering concrete examples and making the researcher's own inferences transparent and comprehensible to the reader. Besides triangulating the results by applying multiple methods, the credibility of the study was further strengthened by sampling more experienced interviewees that were able to provide insights and experiences over longer time horizons.

4.5.2. Transferability

As this study aims to contribute theoretical knowledge about an emerging phenomenon based on a single case study, the main purpose is not universal representativeness. However, limited generalizability does not prevent this research from entering the process of knowledge accumulation. Emphasizing the "force of example", Flyvbjerg (2006) illustratively points out that within the German language, *Wissenschaft* literally means "to gain knowledge". Therefore, the goal was not to develop grand theory from scratch, but to gain a knowledge basis that can advance existing theory and stimulate further research in the field. Furthermore, the details of the case analysis, the specific context, and on what basis conclusions were reached was made transparent. Following the reasoning of Becker (1958), the aim was to enable the reader to make an own judgment whether or not the environment is similar to other situations of interest and whether the findings can be transferred.

5. Empirical insights

Drawing selectively on different data-related innovation initiatives of the municipality and on the personal experiences of interviewees, the case of Copenhagen's approach to developing an encompassing traffic data infrastructure provides indicative examples of how digital technologies are in the midst of changing the practices of public sector innovation. To assist the reader in orientation throughout the case, Table 1 provides basic information on the governing bodies and initiatives that are repeatedly referred to. Table 2 provides a brief overview of the interviewees, the organization they represent and their professional role. As previously outlined (1.2.), the case embarks from the following initial situation: facing the need to identify solutions to gather and analyze big data on bicycle movements, the city's traffic department hosted a collaborative workshop bringing together innovators and interested parties from different sectors. The goal was to co-create viable solutions by combining and further developing existing approaches.

Table 1. Central governance bodies and innovation initiatives referred to in the case

Governance bodies	
Traffic Department	- Subunit of the Technical and Environmental Department of the City of Copenhagen - Responsible for city traffic management, planning and traffic data-related innovation projects - Reports to city government on the accomplishment of policy targets
Copenhagen Solutions Lab	- Created by the City of Copenhagen in 2014 - Accelerator and governance body for Smart City projects - Focus on enabling innovation partnerships between public sector, business, academic institutions and citizens - Focus areas: intelligent traffic systems, reducing carbon emissions, real-time data infrastructure, data sharing platforms
Innovation initiatives	
Big Data Bicycle Challenge	- Collaborative ideation workshop hosted by the Traffic Department in Copenhagen in February 2017 - Goal: co-creating innovative solutions for collecting and analyzing real-time data on bicycle movements - Participants: 53 representatives from municipalities, business, academia, and other interest groups; 10 active innovators presenting solutions
Open Data Copenhagen	- Open data platform by the municipality on which city data is published openly available for download in standardized formats - Examples: data on traffic, parking, physical infrastructure - Project by Copenhagen Solutions Lab

Table 2. Brief overview of interviewees

Name	Organization	Position/role
Bahar Namaki Araghi	Traffic department	Project Leader Intelligent Transportation Systems; responsible for coordinating innovation activities of the department and EU-level initiatives
Emil Tin	Traffic department	Project Leader Technology and Process Advisor Bicycle Program
Jos Van Vlerken	Traffic department	Project Leader Co-organized Big Data Bicycle Challenge
Frans La Cour	Copenhagen Solutions Lab	Responsible for the municipality's data platforms
Jeremy Renton	Citelum EDF	Technology and Innovation Manager Collaborates with City of Copenhagen in developing smart street lighting solutions
Anna Clark	Trivector	Traffic Consultant Winner of the Big Data Bicycle Challenge
Kelton Minor	Copenhagen Centre for Social Data Science	Researcher Winner of the Big Data Bicycle Challenge
Ceri Woolsgrove	European Cyclist Federation	Policy Officer Lobbies for cyclist interests at EU level
Thomas Dale	Climate KIC Nordics	Project Assistant Co-organized Big Data Bicycle Challenge

Adopting a theory-building case structure (Yin, 2014), the following section outlines the main findings of the empirical study along four theoretical arguments. First, it is shown how the use of digitally interconnected technologies is changing the fundamental workings of city management and city life as a whole (5.1.). Second, it is outlined how the increasingly common practice of engaging in cross-sector collaborations affects the management and organization of public innovation (5.2.). The third part describes various attempts undertaken by the municipality to outsource digital innovations and the challenges that currently complicate the creation of a market for public data solutions (5.3.). The final section brings together the political controversies and concerns that were most salient throughout the observations and interviews (5.4.).

5.1. Technology: A data-driven infrastructure to run the city

As the literature review suggested, digital technologies affect Copenhagen's traffic department beyond a mere modernization of existing administrative IT infrastructures. Rather, the emergence of an interconnected data infrastructure seems to profoundly alter the core processes and organizational structures of the municipality as a whole. Gathering, processing, and interpreting data is at core of a new way to think about the city administration's roles and tasks. This argument unfolds as follows. First, it is shown how different types of data are perceived and used to improve decisions within the traffic department (5.1.1.). Second, it is illustrated how the proliferation of digital devices throughout the city introduces higher technological complexity to city management (5.1.2.). Third, it is shown how digital technologies affect the organizational structures and processes of the city administration (5.1.3.).

5.1.1. Hybrid data for improved decision-making and public services

For the three project leaders from the traffic department, collecting and analyzing diverse types of data throughout the city is seen as key to achieving the municipality's policy goals. Describing the growing importance of data, Emil Tin states:

> *"In general, data drives more and more processes and decisions. Data can enable us to make better decisions. [...] All our efforts are related to the overall goal of having a livable and lively city – and all of them require data."*

Based on real-time data on movements and behavioral patterns throughout the city, traffic managers are able to influence traffic flows and individual behaviors, thereby enabling transport solutions that are more sustainable, efficient, and safe. For instance, optimized traffic lights help avoid polluting stop-and-go movements of motor vehicles and congestion, while also encouraging smoother, eco-friendly driving behavior. Other envisaged measures include dynamic traffic signs that communicate current travel times, traffic information and optimal routes to road users (see Figure 4) and intelligent street lighting systems that illuminate bicycle roads and individual cyclists to increase road safety (see Appendix 4)

In the longer run, data on the behaviors of road users can help identify infrastructure needs and ways to motivate citizens to use environmentally friendlier, cheaper and healthier means of transportation such as bicycles. To this end, however, it is crucial to not only get accurate, but also fully representative data. Jos Van Vlerken states:

> *"A major issue at the moment is how to get data on bicycles. By now, we have only data on cars and buses, but leaving out bicycles messes up the accuracy of the traffic data, and thus how traffic is prioritized and further developed in the future."*

Figure 4. Visualization of dynamic traffic sign concept communicating real-time traffic information to road users. (Image source: City of Copenhagen, 2011).

However, real-time data alone is often not enough. To inform traffic planning decisions, big data on movements needs to be complemented with more detailed data on the citizen perspective:

> *"The whole point of getting all sorts of data is to get closer to the lived lives of citizens. What matters in terms of data is often the experience, so how a certain trip is felt. We therefore have a very broad idea of what data is. Besides big data, this could also be qualitative interviews or survey data. In short, anything that informs about the actual behavior of people moving across the city."*
>
> Jos Van Vlerken, Traffic Department

In short, it is thus a large and rapidly growing blend of real-time, historical and social data from different sources that allows not only to track and influence *what* is going on, but also to understand better *why* things are happening in a particular way. This information increasingly forms the basis for improved decision-making in city management.

5.1.2. New devices and socio-technical dilemmas

Part of the newly forming data-based traffic infrastructure is a network of various interconnected devices that become increasingly enshrined in city life. On a more general level, the proliferation of both physical and digital devices to collect data are perceived to lastingly change how people interact with and within their urban environment. For Kelton Minor, researcher at the Copenhagen Centre for Social Data Science, digital technologies profoundly alter how social interactions are shaped by city administrations:

> *"City management has always in some way produced social interactions. But what is new is that there are much more devices: wifi-nodes, new sounds, visual information. There is a new depth or hybridity of the visual and the physical environment."*

At heart of Copenhagen's data infrastructure is an integrated traffic management software system (TMS) where all traffic data is aggregated, processed and visualized. The true challenge, however, lies in the upstream processes required to collect the data. This is especially true in the case of bicycle data. Recalling the experiences of the traffic department, Emil Tin describes the technical dilemma behind bicycle data as one that can only be solved by new ways to combine different physical devices and software. Initial pilot experiments showed that neither sensors installed on bicycles nor a dense web of Wifi- and bluetooth nodes across the city yielded the desired results. First, installing and maintaining a large number of physical devices proved too costly. Second, the approaches provided only volume counts of bicycles passing through pre-determined check-points. What is needed by the department to monitor and optimize cycling traffic, however, is data on the precise travel times and routes of individual cyclists going from a place A to a place B.

In principle, such data can be collected via smartphone apps that cyclists download to track their GPS location. However, such an approach led to representativeness issues as only a small or special group of people used such apps. Therefore, the hope was that during the Big Data Bicycle Challenge innovative solutions could be developed with innovators from the private sector and academia by combining existing approaches and technologies in new and beneficial ways.

5.1.3. From integrating data to integrating structures and processes

Running a complex data infrastructure creates new operational challenges that demand organizational and operational adjustments. To add significant value, data from the dispersed network of hardware and software nodes need to be integrated into the central TMS software in a consistent and standardized format. Therefore, interoperability across projects and departments becomes crucial. Bahar Namaki Araghi, project leader in the traffic department, recalls how the introduction of the TMS initiated a profound integration process throughout the whole municipal organization:

"Previously, there was no centralized traffic management system available. Information was stored in a rather fragmented manner. It was not openly accessible and communicated across different departments within the administration. The new TMS was a very important step to break up these silos."

In order to accelerate the process, the municipality created an organization outside the existing bureaucratic structures of the administration in 2014: leading various data and innovation initiatives, the Copenhagen Solutions Lab today functions as an incubator and accelerator for Smart City solutions. The Open Data initiative, which made selected datasets publicly available in a standardized format, significantly pushed organizational integration throughout the municipality:

"It turned out that open data had a massive impact on internal processes. It creates a focus on efficiency and helps avoid redundancies, by reusing available data and resources. We do not measure the impact in monetary terms, but internal efficiency gains are the main source of benefits and definitely pay for all the open data related efforts."

Frans La Cour, data specialist at the Copenhagen Solutions Lab

The effects of these integrative changes reach beyond the boundaries of the administration. Jeremy Renton, Technology and Innovation Manager at Citelum, a company that collaborates with the municipality in developing digital street lighting solutions, describes:

"Usually, when you run complex technical projects throughout the city, the different silos across all the different city departments become a major problem, especially when data solutions are involved. Everyone is running his own small solutions and everything remains fragmented. The impact then is often limited."

For Renton, initiatives such as the Big Data Bicycle Challenge are a positive signal that this siloed structure is increasingly cracking:

"One of my main observations [from the workshop] was that Copenhagen is currently trying to break the borders between different departments. And I think that this development is very much driven by increasingly data-based projects. That's an important insight for our business."

5.2. Cross-sector collaboration: 'getting the right people to do the right things'

Due to the inherent technological complexity, the high investments, and the uncertainties associated with developing data-driven infrastructures and services, collaborations across sectors become are becoming key feature of Copenhagen's public innovation efforts. This section draws together the main aspects and motivations that characterize Copenhagen's approach to co-creating the future of a smarter city: the conviction that it is important to leverage external capacities to improve the innovation outcomes (5.2.1.); the re-alignment of the administration's operational focus (5.2.2.); and the growing importance of multi-level governance (5.2.3.).

5.2.1. Leveraging external knowledge and capacities

The interviews with public officials suggest that collaborative ideation workshops such as the Bicycle Challenge are indicative symptoms of a much broader shift in terms of how innovation is approached and practiced by the municipality. Having worked as Technology and Process Advisor to the traffic department's bicycle program for the last six years, Emil Tin describes the newly emerging thinking as follows:

> *"Collaborative initiatives are not necessarily only tied to digital solutions. I would say they are rather a new way to look at how to solve things. It is a more easy means to move beyond the traditional boundaries of problem solving."*

For Bahar Namaki Araghi, the changes in the city's wider environment make the idea to reach out to external actors a necessity:

> *"In Copenhagen, there is a strong belief in partnerships. In a world that is getting more and more complex, you simply cannot know everything on your own. To find solutions, you need to get the best of the best, and then form a team."*

At core of this idea lies the conviction that the municipality is not able to develop the best digital solutions internally. Working together with the outside world by bringing the competencies of specialized companies and research institutes on board is seen as a pragmatic approach to produce better outcomes:

> *"Trying to do everything on your own bears a lot of risk. One major risk is what I would call the Nokia risk: at some point, you risk losing sight and ignore the most progressive developments, the technological disruptions that are going on. If you want to be efficient as a public authority, you need to know the best way of doing things. That's why it is so important each time to find the very best partner for each project."*
>
> Bahar Namaki Araghi, Traffic Department

Frans La Cour from the Copenhagen Solutions Lab describes a similar mind-set:

> *"At the Solutions Lab, we are trying to champion a different way of innovating and improving public services. It's about making sure that external actors make the right things happen. Or, to make sure that the right people are doing the right things."*

For him, this emerging division of tasks is the outcome of a learning process the municipality went through initially when it first tried to develop digital services and infrastructures on its own:

> *"The traditional mind-set within the Danish public sector was to do everything by themselves. So, previously, the focus was on developing apps for citizens. But the problem was that these apps were not used. This led to our first open data initiative and the idea to put the system development into private hands. Especially the knowledge-intensive tasks were soon found to be better performed by specialist firms in the private sector."*

Interestingly, despite encouraging the involvement of the private sector in the development and provision of public services, this approach to public innovation seems to differ recognizably from a traditional New Public Management philosophy. Instead of assuming value in privatizing the provision of public services as such, the goal is rather to open the process and identify the right competencies and partnerships on a case-by-case basis. In the words of Frans La Cour:

> *"The main point is not that private sector firms should take on more tasks and responsibilities per se. It is about identifying the best people to do the job in the best way."*

5.2.2. Refocusing on needs, tasks, and processes

For Copenhagen's traffic department, managing a growing number of flexible, collaborative partnerships comes with a new role. As large parts of the actual innovation performance are transferred to external actors, public officials increasingly focus on identifying the most urgent needs, specifying the tasks and setting up the guidelines for the innovation process. However, they remain actively involved despite this opening process:

> *"The role of public authorities should be to give clear directions, communicate goals and ideas about the future, and to raise awareness about the most pressing needs. In a sense, it works very much top-down: if we start with saying 'We want to have a more livable city!', we need to figure out in a next step what this is supposed to mean – for every department, for every domain, for every project."*
>
> Bahar Namaki Araghi, Traffic Department

This suggests a multistep process: in order to manage innovation projects in the interest of the municipality, public officials first translate policy objectives into specific data innovation needs. In a second step, these needs need are communicated to a community of potential external innovators. Jos Van Vlerken explains that initiating and maintaining such a dialogue has been a major motivation to host the Big Data Bicycle Challenge:

> *"We had another big objective beyond creating new ideas. A major goal was also to raise awareness among the private sector and among researchers about the needs we have as the traffic department."*

Subsequently, the department would refrain from interfering too much in the actual design and specification of the solution. Araghi states:

> *"I would ideally not even frame a clearly defined challenge. I would instead make a hackathon, leave the way an issue is approached open, and let the genius people come up with the best design ideas. Then I select the winner and use the project's budget to support them finalize the product. That would be much cheaper, more innovative solutions would come out of it, and it would mean to completely break up with the former tradition of doing everything ourselves."*

The concept of the Big Data Bicycle Challenge mirrors this thinking. At the beginning of the event, participants were provided with rather open evaluation criteria that winning proposals would have to meet. First, solutions should be easily adoptable by cyclists, ideally avoiding extensive efforts to be undertaken and even incentivizing the use. Second, solutions should be technically feasible, allowing for high data accuracy without excessive costs. Third, solutions should be based on viable business models allowing for high scalability. To this end, a

business coach assisted participants during the workshop in refining the business case of their idea. Finally, ensuring privacy of cyclist data was repeatedly stated as another key criterion. After selecting three winning proposals based on these criteria, winners would be provided access to parts of the city infrastructure as testing grounds.

5.2.3. Multi-level governance

The case of Copenhagen makes clear that Smart City innovation entails the need to coordinate different collaborations at multiple levels. As the scope for searching for potential partnerships and existing solutions extends beyond Copenhagen's city limits and Denmark's borders, a number of mediating organizations function as facilitators and connectors.

First, public-private partnerships such as Climate-KIC, which is partly funded by the European Union and dedicated to advancing climate-friendly innovations across the EU, try to connect different collaboration partners and share knowledge and best practices across different countries. Concretely, Climate-KIC provides startups and municipalities with additional funding and a valuable network of organizations for climate-smart innovation projects. Thomas Dale from Climate-KIC describes his organization's role as follows:

> *"The purpose of Climate-KIC really is to be a facilitating organization within the space that is left between academia, municipalities, business and to some extent also civil society. […] Although many municipalities try hard to promote innovations, public officials often do not have the time and resources to explore a lot themselves. That is where we can step in and accelerate and support the process by bringing in additional ideas, contacts, competencies and resources."*

In Copenhagen, the Big Data Bicycle Challenge was co-hosted and moderated by Climate-KIC. Moreover, the workshop was partly financed by a grant from Climate-KIC which Copenhagen's traffic department had previously applied for. The winners of the challenge were accepted to Climate-KIC's Europe-wide accelerator program aimed at further refining and testing promising ideas.

Second, a lot of data innovation initiatives undertaken by the traffic department are directly embedded into larger innovation and funding programs of the European Commission. For instance, the EU Horizon 2020 program allocates funds amounting to €80 billion from 2014 to 2020 to public research and innovation programs (European Commission, 2017). For Bahar Namaki Araghi, both the funding and network provided by such EU frameworks is crucial for initiating highly innovative projects. A key activity of public project managers thus consists of actively securing such support while, at the same time, monitoring and translating new European standards into local innovation practices.

5.3. Public needs, private solutions – toward a market for citizen-centered data innovations?

The previous sections have shown how data-driven innovations in Copenhagen go hand in hand with a transition toward more collaborative practices of public sector innovation. While this transition can be understood as an opening process compared to previously more closed innovation models, it also entails the growing outsourcing of innovation activities to external market actors. This section therefore addresses another theme that frequently recurred during both the Big Data Bicycle Challenge and the interviews: the difficult relationship between public innovation needs and a market for public data solutions that still seems to be in the making. In the following, observable traces of challenges and strategies are outlined that might be characteristic for a changing market dynamic: current barriers to a fully functioning market for data solutions (5.3.1.); and early-stage interaction prior to commercial transactions (5.3.2.).

5.3.1. A market that is not yet ready

The interviews with project leaders from the traffic department and company representatives are indicative of an emerging mindset according to which public demands for data-based traffic innovations can often be satisfied best by the market. At the same time, the experiences made in Copenhagen show that creating such a market for citizen-centric solutions currently remains an unresolved challenge.

Bahar Namaki Araghi describes the envisaged approach as follows:

> *"[…] We don't need public procurement in every case. It often makes much more sense to let the market develop the services and solutions. Of course, public authorities should always have a role, but they should act more like an enabler. […] Public authorities often do not need to be involved any further than providing the digital infrastructure. They can simply let others develop the solutions, and if the service is good enough, it will be used by the citizens."*

This increasingly market-oriented thinking is also reflected by Frans La Cour's description of how the way public authorities approach digital technologies has evolved over time:

> *"Initially, there was a lot of buzz and fascination for the new technology. But now the situation is a lot more mature. We now focus on the business case of creating and using data. We start by identifying: 'Where is the demand for data?' 'How could [data] be used effectively?'; 'Do the benefits outweigh the costs?'; 'Is it a valid business case and worth doing it?'"*

For Frans La Cour, the Big Data Bicycle Challenge is a direct outcome of this development. In fact, the idea to "create a market for data solutions" and to "co-create market innovations" was repeatedly stated by the workshop moderators (see Figure 5). However, observations of the interactions of the participants during the workshop as well as the short conversations with participants revealed how difficult it can be to actually make competing private companies collaborate for the public good: while few deeper interactions took place between the participants during the ideation phase beyond networking, the project managers in the traffic department in the end perceived the firm's final pitches rather as sales pitches for the company's existing solutions. For Bahar Namaki Araghi, the outcome of the workshop indicates that it remains problematic to leave the solutions to a market that still needs to form:

> *"The ideas I've seen during the workshop are all 'good'. But, to be honest, for me there was nothing with a real 'wow factor'. What's been presented is mostly known. It shows again that the market for providing such data is simply not there yet."*

Figure 5. Excerpts from the presentation given by project managers from the traffic department at the beginning of the Big Data Bicycle Challenge to set the scene and communicate the expectations of the workshop.

Similar problems have previously been encountered by the Solutions Lab in the attempt to stimulate market innovation by publishing available data in hopes that startups and established firms would create service solutions on top of it. Frans La Cour describes the learnings from this experiment as follows:

"Actually there's not much innovation going on in open data. There is a dichotomy between open data and innovation: Open data is usually public and free, which means that from a business perspective, it is rather low value data. What businesses want, for instance to build the next Uber of Copenhagen, is more exclusive data. Innovation is only one of many purposes behind open data, and it is, at least in my view, not the main one."

Looking ahead, Frans La Cour believes that the solution to overcoming these barriers toward creating a functioning market for public data solutions might involve even closer collaboration with the private sector:

"The ideal mechanism for the future would be a cyclic feedback loop, reflecting an even more interactive relationship between the public and the private sector. Demand by the citizens would stimulate solutions developed by the private sector, lessons would be drawn from the results, and these lessons will again translate into new demands, and so on."

However, from the perspective of the private sector, Anna Clark, consultant at the Swedish traffic consultancy Trivector and one of the winners of the Bicycle Challenge, the rapid technological progress itself might be the reason for a wait-and-see attitude regarding private investments:

"Technology advances so fast that everyone has trouble to keep the pace. Take the research that is published now: what it describes is usually already two years outdated. There is so much technological progress going on in the meantime. Nobody has really got their think on what practical potential is in data and what business models can be derived from it to use it."

5.3.2. Pre-commercial procurement and early-stage networking

As there are often no satisfying Smart City solutions on the market, all interviewees from the municipality and the private sector emphasize the value of engaging in early-stage collaborative research and innovation projects. For instance, before issuing a large tender for the acquisition of the TMS, the traffic department had worked closely with a variety of firms to first specify the exact needs of the system and prototype potential solutions. This 'pre-commercial procurement' phase was open to every firm willing to commit time and resources despite the risk of eventually not getting the contract. This approach is seen to have several benefits:

First, it helps both parties to understand the technical requirements of an effective data solution in a field that is often unknown territory. Referring illustratively to the experiences of such projects under high uncertainty, Frans La Cour explains:

> *"The problem is usually not so much that the private sector and the public sector are not on the same page. The problem is more that they both do not know what page they are on."*

Second, the outcome and cost-efficiency of such joint efforts involving upfront investments of both public and private organizations are typically found to improve compared to traditional procurement in highly innovative projects. One reason for this is found to be that the traditional distribution of roles of having one customer and one provider is vanishing:

> *"In this alliance model, since all the parties want to win together, they use their best employees and resources and all of them try to optimize the project's progress together to save budget and time by being efficient and innovative. It's either we all win, or we all lose."*
>
> Bahar Namaki Araghi, Traffic Department

Third, establishing contact at a very early stage of the innovation process provides companies with an opportunity to better understand the needs of public clients, thereby increasing their chances of being awarded the contract at a later stage:

> *"We aim to provide whatever solution fits the client's needs. So for us, the more we are involved in this process the more we can find out about and adapt to the needs of our clients. That's the big advantage of these collaborations for us."*
>
> Jeremy Renton, Citelum

Recalling the past experiences of the traffic department's early-stage collaboration prior to the large TMS tender, Jos Van Vlerken emphasizes that the benefits for both firms and municipalities can be substantial:

> *"It was obvious that the more contact the firms had previously with the department, the better the quality of their proposals during the later tender was. In my view, this can be generalized to encompass all relations between business and their public sector clients. Whenever businesses take the opportunity to really listen to their clients' needs, the outcomes improve."*

Finally, the example of the Big Data Bicycle Challenge shows that opportunities for early networking can be created without major investments and planning efforts. All interviewed participants named networking with the municipality, potential clients and other players in the field as a primary motivation to attend. Kelton Minor, researcher at the Copenhagen Centre of Social Data Science, states:

> *"Especially for scientists, it is very helpful to get to know about the pragmatic needs from a city management perspective. The workshop was also perfect for generating relationships and making contacts."*

5.4. Political controversies and concerns

A closer look at the current data-related challenges of Copenhagen's traffic department not only provides a selective impression of how digital technologies have begun to alter the dynamics within city management, collaborative innovation practices and a market for public data innovations. The case of Copenhagen also suggests that these interconnected changes raise several political controversies and concerns among different stakeholder groups. Opening spaces of political contestation around issues that extend beyond the traffic department and Copenhagen, the outcome of these controversies seems likely to have a significant impact the further pathway of public sector innovation practice. This section outlines the three issues that were most salient during the observations and interviews: the challenge to reconcile sometimes conflicting commercial and public interests (5.4.1.); the need to design not only technologically smart, but also socially inclusive data infrastructures (5.4.2.); and finally, the ubiquitous privacy-related concerns that are fueled by data-driven solutions (5.4.3.).

5.4.1. Reconciling multiple values and interests across sectors

The interview responses suggest that private and public sector organizations enter collaborative innovation endeavors equipped with partly different values and interests. While firms seek to maximize the commercial value of the innovation process, the traffic department needs to balance a whole set of multiple public values besides economic growth and efficiency, including road safety, health- and environment-related considerations, and the overall quality of life in the city. Reconciling these different logics thus adds a substantial political dimension to the newly forming innovation practices. Consequently, it is found that public and private organizations have different approaches to how they understand the meaning of 'Smart City innovations':

> *"While firms primarily attempt to sell their tailored solutions, we still try to figure out 'What is it?' and 'How can we make use of it?'"*
>
> Emil Tin, Traffic Department

Two issues illustrate how the confluence of commercial and public values can become sources of concerns and barriers to innovation. First, to maintain impartial competition and independence, the traffic department needs to keep the innovation process open and avoid technological lock-ins that could make the municipality overly dependent on a single company. This conflicts with a firm's interest to obtain the largest possible share of a contract. In Emil Tin's words:

> *"There are different interests at play when private and public organizations work together: [...] we want to integrate the data from different sources, but companies rather want to promote their solutions, their own solutions that does it all."*

In turn, and somewhat ironically, this problem opens a door for firms that have adapted their business model to mitigate this problem by combining hard- and software from other ICT firms as a service. Jeremy Renton from Citelum explains his company's approach:

> *"Of course, we seek to influence the city administration in favor of our company's approach rather than favoring a single company solution. We function more as a facilitator or mediator that assembles a fitting solution from different sources. We might not have our own products, but we have legs and feet. And we are usually cheaper than highly specialized technicians. In the end, we try to establish ourselves as the single contact point for all the different departments and projects run by the city."*

Second, commercial interests are sometimes perceived as barriers to innovations that are primarily intended to serve the public good. According to Jos Van Vlerken, early-stage collaboration and dialogue efforts can easily be thwarted by commercial goals if participating companies attempt to disguise existing solutions as the outcome of collective and needs-based ideation:

> *"Issues arise when businesses mistake opportunities to listen for opportunities to sell existing products. This can become quite tiresome sometimes."*

5.4.2. Inclusiveness

The challenge of collecting accurate data on cycling behavior nicely illustrates a major concern of public officials trying to design socially inclusive data solutions: as it is technically easier to collect data on cars, traffic data risks to overly represent certain groups of the population. In fact, some of the most intensive discussions among the participants of the Big Data Bicycle Challenge revolved around the concern that a data bias toward interconnected cars in inner city districts would lead to a policy-making bias in favor of socio-economically privileged groups. This is why inclusive traffic innovations seemingly require socio-economic background data about individuals to complement data on behaviors and movements. Kelton Minor, researcher at the Copenhagen Centre of Social Data Science, therefore argues that traffic data strategies should be centered on the idea to capture the diversity of people's lives in the city:

> *"In a sense, [running a Smart City] is like a map maker trying to create a map. Leaving out some groups would risk creating blind spots on the map. For me, the challenge behind the idea of Smart City is essentially about how to meet all the people where they actually are."*

Moreover, the issue of data representativeness entails substantial concerns that certain interest groups are more powerful in influencing the traffic data agenda than others. The tensions regarding political power imbalances in the design of Smart City solutions became clearest in the interview with Ceri Woolsgrove, who lobbies for the European Cyclist Federation at EU level to raise awareness about the interests and needs of cyclists:

> *"The threat in the Smart City discussion is that a lot of the talk focuses only on cars and autonomous vehicles. One of our main concerns is that we want a seat at the table. This is our main focus in our lobbying strategy: We don't want to be left outside the room when publics and carmakers discuss the future of urban mobility."*

According to Woolsgrove, the differences in power are persisting relics of a car-oriented approach to urban planning that remain influential in the data-driven age at the cost of cyclists' interests:

> *"Cycling has been sidelined in the concrete infrastructure for decades. Now the threat is to experience this again with a new type of infrastructure: the data infrastructure. Although it is a new type of infrastructure, it is still the same lobby and the same contracts involved. And we worry to be sidelined again."*

Finally, concerns related to inclusiveness also include gender and diversity issues. A seemingly trivial observation may point toward the risk of a gender bias toward men: out of the 53 participants of the Big Data Bicycle Challenge, only six were women. Out of the ten innovators that actively pitched potential solutions, only one was female. For one female attendee of the workshop, the framing of innovation challenges as well as the naming of collaboration formats have a decisive impact on the number of participating women:

> *"The name 'Big Data Bicycle Challenge' sounds highly technical. This in itself is not the problem, there is plenty of women that are highly skilled in these technologies. What I mean is that probably a lot more women would be attracted to such workshops if the challenge were framed differently, emphasizing more the social and societal dimensions of data. What if, for instance, the workshop had been named 'How to build a more inclusive data infrastructure for Copenhagen?'"*

According to Anna Clark's experience as a consultant, diversity in the data innovation process can affect outcomes:

> *"If a very similar group works together, they tend to develop solutions that are primarily good for them. They do not think much or do not understand others outside the group. This is the big risk in tech: That you develop apps that are only great for one group. [...] But of course, there are more ways to increase diversity, including more women is only one of them."*

These insights suggest that collaborative efforts aimed at enabling data-driven public innovations, which tend to have a profound impact on city life and society as a whole, do not include the diverse needs and thinking of different population groups by default. This leaves public officials entrusted with designing and managing the innovation process with the challenge to constantly reflect and evaluate if the needs of all stakeholders are represented in both the data infrastructure and the data itself.

5.4.3. Privacy

The bicycle data-related challenges of Copenhagen's traffic department further make clear that the design of viable data infrastructures is closely intertwined with legal and ethical privacy issues. To unfold its full potential for traffic management and to ensure socially inclusive innovations, data on movements and behaviors need to be complemented with personal information on the motivations for certain trips and route choices as well as the socio-economic background. A participant's comment during the Bicycle Challenge pinpointed the fundamental underlying conflict of personalized traffic data:

> *"Just storing data anonymously is not enough. If you track people regularly, you will eventually have a frequent address as a starting point, which is likely to be the home address. And from there it's only a small step to find out about a person's name, job, love affairs, and so on."*

Consequently, data-driven innovations create multiple privacy-related dilemmas that yet need to be resolved by public officials. First, it seems that existing privacy legislation and data innovations are caught in a relationship of mutual conflict in which it is not entirely clear who is having the upper hand. On the one hand, Bahar Namaki Araghi states that privacy law currently prevents the traffic department from fully exploiting the potential of existing data solutions as a lot of the data that is bought from analytics companies must be deleted. On the other hand, the reality seems already pervaded with data practices that at least fall into a regulatory grey area. Kelton Minor describes the situation as follows:

> *"Regulation is chronically lagging behind the actual situation evolving around privacy issues. It is essentially a reactive game in which regulation is always late."*

As a consequence, the validity of current privacy regulation seems to be increasingly called into question. During the Bicycle Challenge, one participant commented that although ethical standards in big data matter, everyone in the room owning a smartphone would produce highly personalized data in that very moment, sending it to private tech companies such as Facebook, Apple, and Google. In this context, Araghi raises the question if current privacy laws still represent contemporary attitudes of citizens:

"[...] How do we know if people even care so much about their GPS location data? After all, they are posting much more sensitive things such as personal pictures publicly on Facebook."

This question points toward a second critical issue: who legitimately owns the data that is produced not just by cyclists, but by citizens more generally? Several contributions to the privacy debate during the Bicycle Challenge supported the intuition that public institutions genuinely concerned about environment, health and public wellbeing should have an advantage over primarily profit-oriented organizations regarding the collection and usage of personalized traffic data. Interestingly, participating researchers like Kelton Minor highlighted that close collaborations between public and academic institutions in experimental projects with sensitive data in a transparent framework could present a possible way forward:

"As researchers, we can contribute a different and more critical perspective on data and privacy issues. We can help innovate new and effective privacy practices in a completely different and much more protected environment."

In situations where privacy regulations and concerns may hamper data innovation within public-private collaborations, academic research projects could thus provide an opportunity to still practically test and experiment with potential solutions in a more neutral, scientific setting prior to commercialization or implementation by the city administration.

5.5. Concluding remarks

The empirical insights into the mechanisms and challenges behind designing a new traffic data infrastructure in Copenhagen substantiate the initial intuition that digital technologies alter how innovation is approached and practiced in a public innovation context. In the form of various interconnected physical and digital devices, new technologies are at the center of an innovation dynamic that increasingly involves open forms of collaboration to identify not only technical, but also conceptual data solutions for a more sustainable and livable city. Managing and coordinating such innovation processes across multiple sectors and organizational boundaries not only places new demands on public officials; various initiatives to create a market for data-based service innovations and to collaborate in early-stage research projects contribute to a changing market dynamic for public sector contracts. The interplay of these changes raises several political issues which currently remain controversial among the different actors.

6. Discussion

Based on the empirical insights, this section applies the previously developed theoretical lens to provide tentative answers to the pre-formulated research questions. First, emerging practices are outlined that seem to be characteristic for a forming action net for public sector innovation in a Smart City context (6.1.). Second, propositions regarding the main actors involved and their respective roles are made (6.2.). Third, the central political challenges behind a newly emerging dynamic of public sector innovation are synthesized (6.3.). Finally, the analysis is condensed into a tentative framework that, based on the specific case of Copenhagen, exemplifies the dynamics of a forming action net for Smart City innovation. On this basis, potential implications for decision-makers in public and private organizations are discussed (6.4.).

6.1. Emerging practices characterizing public sector innovation in Smart Cities (RQ 1)

The study made clear that innovation processes in a Smart City context comprise many interrelated activities. Yet the findings allow to point out traces of three emerging practices that, driven by digital technologies, play a particularly decisive role in holding together a novel approach to public sector innovation in Copenhagen. While it would go too far to speak of already fully routinized practices (Reckwitz, 2002), they are indicative 'proto-practices' (Shove & Pantzar, 2005) of a growing need to create and maintain new links between different actors and work across organizational boundaries and sectors. As such, the following practices seem paradigmatic for a newly emerging approach to city governance, in which bringing the right partners together in collaborative initiatives is seen as key to meeting the innovation challenges of the digital age.

Framing and communicating public data innovation needs

The example of Copenhagen's traffic department shows how the need for technology-enabled public innovations puts public administrations in a demanding intermediary position. In the language of ANT, this position involves extensive translation work: first, public officials need to translate the political vision of the municipality (e.g. the goal to become carbon-neutral by 2025) into measurable, traffic-related sub-targets (e.g. increasing the share of bicycles to 50% by 2025). Second, these targets need to be translated into concrete and prioritized innovation needs. The case of the bicycle data has shown that the process of searching and thinking about potential solutions is, at least in the field of transportation, increasingly governed by the possibility to gather and analyze different forms of data for central traffic management systems (e.g. real-time data on cyclists' movements). Third, these specified public innovation needs need to be communicated to a network of potential external innovators. Continuously framing and pro-actively communicating the municipality's innovation needs therefore is not only a precondition for bringing potential innovation partners together; it is also the starting point for the underlying organizing dynamic of the subsequent collaboration process.

Collaborating in ideation, research and development

Copenhagen's approach to co-creating a functioning data-infrastructure together with external actors in different innovation formats can be seen as the outcome of a longer trial-and-error learning process. The emerging practice of outsourcing substantial parts of the innovation performance to private and academic organizations in different collaborative arrangements is driven by the pragmatic recognition that in a complex urban environment, often neither public organizations nor market actors can develop satisfying data solutions on their own. Challenges such as gathering useful data on bicycle movements thus present a new type of socio-technical innovation problem that require joint innovation efforts across sectors. However, the opening of the innovation process does not necessarily lead to a privatization of public data infrastructures or services. Neither do new forms of collaboration necessarily replace traditional public procurement as such. Instead, the findings suggest a more nuanced prospect: although increasingly becoming an integral part of a growing number of Smart City initiatives, collaboration can more generally be seen as a complementary upstream process in the innovation toolkit of public officials in Copenhagen. The insights gathered in collaborative ideation and research initiatives can put public officials in a position to make more informed decisions: on a flexible case-by-case basis, they can determine how a given data solution can best be developed, and by whom.

Multi-level networking

As much as Smart City technologies are about digitally connecting different devices, data sources, and people, Smart City innovation often seems to crucially depend on the ability to connect suitable collaboration partners at a very early stage of the innovation process. In Copenhagen, networking practices take place in different formats and across different levels. While ideation workshops and pre-commercial research projects provide platforms for networking between firms, the municipality and academia, additional hybrid organizations such as the Copenhagen Solutions Lab and Climate-KIC continuously work on establishing links between different actors. For public administrations more generally, this indicates that both setting up a separate municipal governance body and pro-actively reaching out to like-minded municipalities and organizations can be effective means to facilitate the creation and maintenance of a flexible network of innovators at both the local and the international level. In the private sector, such networking opportunities allow firms to identify current needs of public clients as well as potential business partners. Therefore, multi-level networking – understood as the creation and maintenance of a flexible network of potential innovators that enables constant cross-fertilization and knowledge sharing – can be seen as another emerging key practice of Smart City innovation.

6.2. Main actors and their roles in the innovation process (RQ 2)

In Copenhagen, the decision to use digital technologies to build a more sustainable and livable city introduced new organizational and non-human actors that actively shape the dynamics of public sector innovation. Moreover, a data-driven approach to city governance altered how established actors understand their roles within the process. Table 3 summarizes what tentative propositions can be formulated based on Copenhagen's example regarding what main actors are involved in Smart City innovations and what their respective roles are.

Within the public sector, a guiding vision is established through a political process at city government level. This vision sets the political priorities around which individual departments and governing bodies throughout the municipality seek to design specific action plans. Next, project managers in city departments assume a critical role in identifying data-based solutions to achieve the policy objectives. The findings of this study strongly suggest that the role of administrative departments concerned with traffic- and environment-related issues is evolving: rather than just 'administering' policy directives within established bureaucratic procedures, public officials act as orchestrators of a networked, dynamic and collaborative innovation process. In this role, they not only connect different actors outside of the administration, but also constantly evaluate potential solutions under considerations of multiple public values. Meanwhile, separate governance bodies within the municipality act as facilitators between public, private and academic organizations. A similar role is played at the European level by thematically focused public-private organizations such as Climate-KIC.

Within the market sphere, firms take on the role of solution developers. While they contribute specialist knowledge and additional resources needed to develop satisfactory data infrastructures, companies may also provide new data-based services that complement or even substitute public services. More than just developing technical innovations based on requirements that are pre-defined by public clients, data-driven innovations thus offer opportunities for market actors to shape new ways to organize and manage city life.

Regarding the role of academia, the evidence provided by this study is not as clear. The observations during the Big Data Bicycle Challenge suggest that academic institutions can act as neutral collaboration partners in more sensitive innovation projects involving data-related privacy concerns. Although this study did not capture how such projects are set up and carried out, the findings suggest research might play a strategically important role in further advancing Smart City innovations beyond the contribution of scientific knowledge: especially when public and private organizations may, from a citizen perspective, lack the legitimacy to test data solutions that risk to conflict with civil liberties, embedding the innovation process into a clearly demarcated research project may offer a way to balance technological progress and political concerns.

Table 3. Propositions about central actors and their respective roles in Smart City innovation

Actor	Role	Main tasks/impact
City government	*Visionary*	Formulates political vision and defines priorities for Smart City development
Administrative department	*Orchestrator*	Defines and communicates innovation needs and technological requirements;
		Coordinates network of potential innovation partners and manages collaborative projects across sectors;
		Tests solutions, evaluates outcomes and gathers feedback from users/citizens;
		Reports back to city government
Smart City governance body	*Local facilitator*	Connects potential innovation partners from public, private, and academic sector
		Initiates and coordinates comprehensive Smart City initiatives spanning across the multiple departments and industries
EU innovation programs and public private partnerships	*Multilateral facilitator*	Provide funding and network for Smart City innovation projects
		Connect and share knowledge among municipalities, firms and academic institutions
Private firms	*Solution developer*	Develop technical solutions
		Complement and/or substitute public services
Research institutes	*Non-commercial partner*	Provide scientific knowledge
		Can carry out politically sensitive studies in academic environment
Citizens	*Pro-user*	Produce personal data and traffic data
		Use physical and digital infrastructure
		Give feedback and influence political agenda through elections
Data infrastructure	*Integrator*	Influences decision-making, specification of innovation needs and evaluation of potential solutions
		Creates need for integration of processes and organizational structures throughout the municipality
		Creates need for collaboration across multiple organizations

Citizens in a digitally interconnected city seem to assume a hybrid role: on the one hand, equipped with various technical devices such as smartphones, they become producers of personal traffic data that informs the decisions of public officials. On the other hand, as the eventual users and beneficiaries of a smarter and greener city infrastructure, they create the demand for public data solutions. Acting in this 'pro-user' role, citizens and their involvement therefore present another focal node in the action net for Smart City innovation.

Finally, this study provides support for the idea that a data-driven approach to city management includes a new type of non-human actor that has a decisive impact on the dynamics of public sector innovation. Data infrastructures, for instance with a traffic management software at their core, seem to act as an integrator across the boundaries of different public and private organizations. Consequently, the logic of integrating data pervades how processes are organized throughout the municipality and how innovators evaluate potential solutions. As data-based solutions need to be compatible with existing elements of the city's data infrastructure (e.g. an integrated traffic management system), the influence of digital technologies on evaluation and decision-making processes can be expected to rise steadily as Smart City development progresses. Therefore, seeing digital technologies as a mere technical means to achieve pre-defined goals or perform established routines risks being overly simplistic. Rather, technology plays an active role in shaping the definition of innovation needs and the organization of innovation processes.

6.3. Smart City innovation as political innovation (RQ 3)

The seemingly trivial case of bicycle data strongly suggests that leveraging digital technologies in city governance adds substantial political dimensions to the dynamics of public sector innovation. The need to make delicate trade-offs between multiple public values became most clear in the omnipresent juxtaposition of becoming a greener and more livable city on the one hand, and the need to protect privacy-related civil liberties on the other. Consequently, the technical dilemma of technological innovations such as bicycle big data is essentially political: on the one hand, designing a useful and inclusive traffic data infrastructure is to a large extent about understanding the details of social interactions and personal movements throughout the city. On the other hand, retracing the micro-movements of people through sensing technologies (Eagle & Pentland, 2006) ultimately allows to recount their life stories, make predictions about their behavior and influence their choices. As these capabilities can be used for good and bad means, it might thus be only a small step from the vision of a Smart City toward the reality of a 'panoptical city' (Kitchin, 2014). These issues bring up fundamental political questions that need to be answered in the innovation process: What does it mean to build a both environmentally and socially sustainable city? Who is a data-driven city infrastructure going to be for, and what will it look like? And what compromises are urban citizens willing to make in terms of their privacy rights?

It seems evident that the involvement of citizens in equal terms is a crucial part to reaching politically legitimate conclusions with regard to these questions. Although citizens were not directly involved in the collaborative innovation initiatives presented by this case, it became clear that the innovation process does not work entirely top down. The fact that it is ultimately citizens that produce the needed data requires public innovators to think of ways to gain people's trust and make them buy into the idea of sharing personal data in return for improved citizen-centric public services. Conversely, as the public value of personal data can only unfold when it is shared, citizens similarly face the need to weigh values like sustainability and quality of life against privacy concerns. Therefore, reaching a societal consensus and advancing the Smart City agenda seemingly requires having a broader political debate about how to rethink privacy and data sovereignty in the digital age.

Finally, Copenhagen's example shows how Smart City innovators constantly need to balance commercial and public interests. First, while close cooperation with private firms is a precondition for achieving policy objectives, such intimate ties may also have the potential for corruption and a bias toward already established partnerships. In Copenhagen, public officials make conscious efforts to maintain a sufficient level of competition and independence throughout the innovation process. However, as the example of the European car industry lobby shows in the case of traffic data infrastructure, existing power imbalances between different societal interest groups and industries may subtly lead to biased political agendas and data infrastructures.

Second, evaluating different data solutions based on immediate cash value may lead to different conclusions than evaluations based on long-term public value. The experiences made in Copenhagen indicate that firms engaging in collaborative innovation may originally have the incentive to push for existing solutions that maximize their financial returns. However, the study also provides early indications that political considerations increasingly enter the commercial sphere: as developing a long-term competitive advantage in part means becoming and remaining part of the community of external innovators, some companies increasingly see an advantage in using early and pre-commercial collaboration practices to develop solutions tailored to the municipalities' actual needs. This means that public and commercial values do not necessarily stand in contradiction. Instead, both logics have substantial common ground in striving toward long-term value creation and cost-efficient innovation projects.

6.4. Strategic implications (RQ 4)

Based on the previous discussion, figure 6 synthesizes the dynamics that shape a forming action net for data-driven public innovations in Copenhagen. It is important to restate that in its proposed form, the depicted dynamic is closely linked to the particular context of the City of Copenhagen. Nevertheless, the underlying patterns allow for a few tentative conclusions regarding the wider strategic implications for decision-makers in public and private organizations.

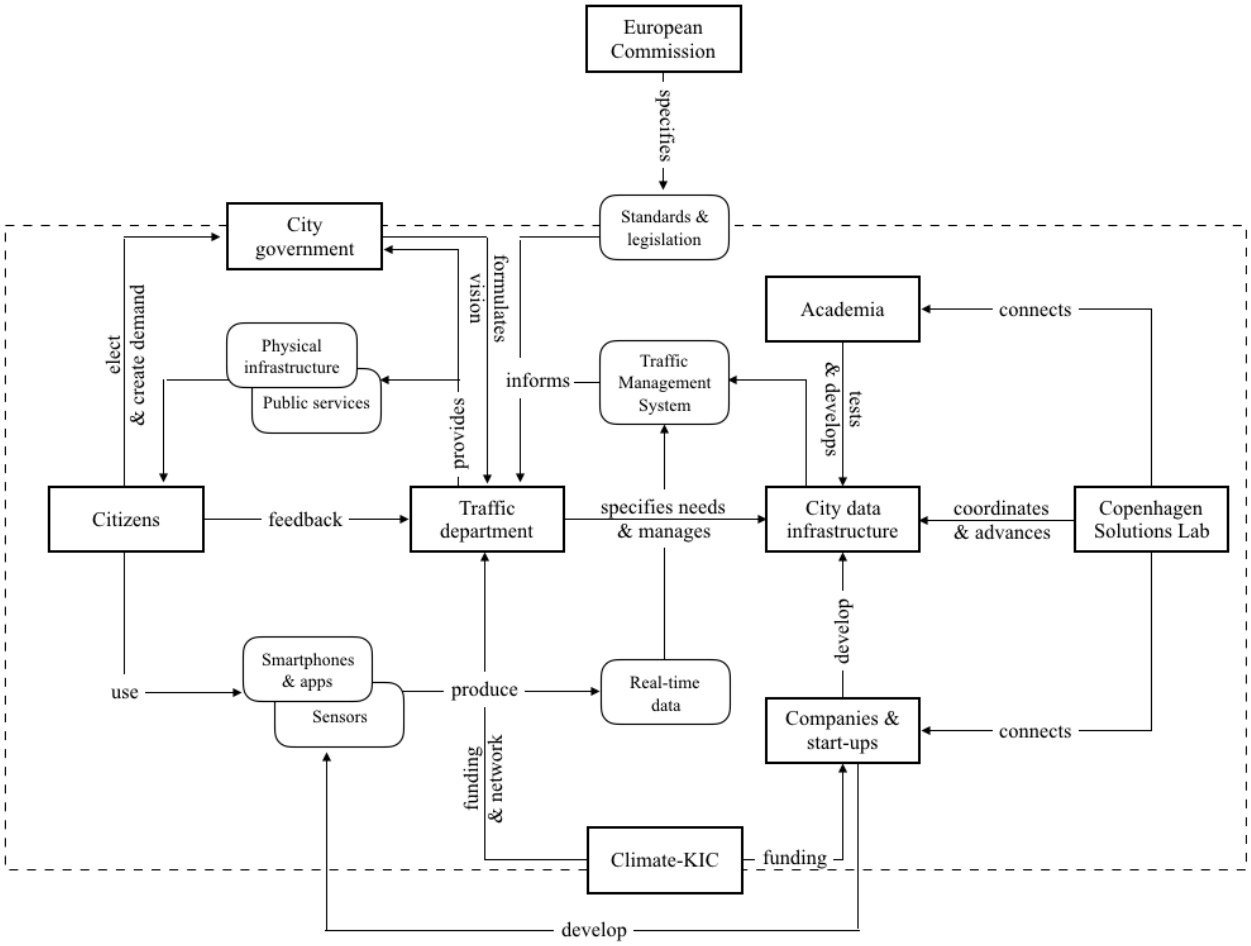

Figure 6. Illustration of the forming action net for data-driven public sector innovations in Copenhagen

In its illustrated shape, the action net mirrors a highly flexible organizing dynamic. While a new set of practices in principle enables new frameworks for collaboration across different sectors and governance levels (see 6.1.), the eventual composition of actors and their respective associations is not set in stone. Instead, the action net for data-driven innovations is constantly reconfigured, depending on the technological particularities of a given innovation challenge. Viewing a forming city data infrastructure as a central actor further allows to explain in more detail how digital technologies establish new links between human and organizational actors, thereby altering their respective roles and tasks (see 6.2.). Moreover, by visualizing how interconnected smartphones, sensors, and analytics software such as the TMS allow to produce and aggregate real-time data, the action net perspective highlights the crucial intermediary role played by new digital and physical devices – both in creating a dynamic data infrastructure and new social interactions throughout the city.

For public officials seeking to shape the innovation process for citizen-centric outcomes and in the public interest, these mechanisms have important strategic implications. First, public officials face a paradoxical challenge with regard to their relationship to external innovation partners. On the one hand, external actors increasingly need to be involved closely in collaborative relationships. On the other hand, municipalities need to maintain a high degree of flexibility to avoid dependencies on individual innovation partners and technological lock-ins. Therefore, and similar to considerations in social network theory (Uzzi, 1997), constantly embedding the innovation process into a balanced action net of sufficiently close ties with private innovation partners while at the same time keeping an adequate distance becomes a key concern for public officials. Second, the findings suggest that among the many new connections digital technologies create in Smart Cities, an intensified relationship between public administrations and citizens is of particular importance. In an ambiguous innovation process that entails both legal and ethical considerations, public officials need to rely on robust criteria and principles to transparently evaluate different options and make decisions in the long-term interest of the public. Such citizen-centric guidelines can only be developed and continuously refined through a close and participative dialogue with the local community.

For the private sector, a flexible action net for Smart City innovation presents a new market dynamic. The emerging practice of early collaboration prior to commercial transactions casts doubt on the effectiveness of preconceived marketing activities and sales pitches. Rather than trying to strike large contracts with prepackaged solutions quickly, a more patient approach based on carefully listening to the individual needs of municipalities might provide better returns and business relations in the long run. Moreover, opportunities for new market entrants and service-oriented business models might emerge in response to the growing complexity of managing a city data infrastructure and the formation of market for citizen-centric data-based services. However, new entrants are likely to face resistance by still powerful incumbent industries and large ICT firms trying to defend their position (Fligstein, 1996).

7. Conclusion

The overarching objective that has motivated and guided this thesis was to investigate how digital technologies affect the dynamics of public sector innovation at city level. Taking the City of Copenhagen's approach to Smart City innovation and the particular challenge to develop a public data infrastructure for bicycles as an example, an explorative study combining observations and in-depth interviews has allowed to unravel signs of a changing approach to public sector innovation and city governance.

The study's findings suggest that by rewiring how people, material devices and organizations interact throughout the city, digital technologies drive a public innovation dynamic that entails new practices, actors and political controversies. In essence, the example of bicycle traffic data provides empirical support for the idea that a data-driven world comes with new forms of city governance: as environmentally and socially desirable data infrastructures cannot be procured or designed by single organizations in a satisfactory way, the emerging governance practices identified by this study are characterized by the need to manage different forms of collaboration across different sectors and spheres of society.

By illuminating how these collaborative efforts are shaped and organized within a flexible action net that links various organizational, human, and non-human actors, it could be shown that there is currently no standard approach to Smart City innovation. Furthermore, the design of both public data solutions and frameworks for cross-sector collaboration has been found to give rise to sensitive political dilemmas within the public innovation process and to altered market dynamics for public data infrastructure contracts and services.

While the dynamics and issues pointed out by this thesis rest on a single case study of the City of Copenhagen, municipalities around the world face similar needs for wide-ranging technological innovation to master the challenges of the 21st century. For some of these municipalities, bicycles and big data on cyclist behavior might not exactly be the first things that come to their mind when crafting a Smart City strategy. The findings of this study may contribute to a heightened awareness among policy makers that, if embedded in a clearly defined political vision and collaborative forms of governance, digital technologies can in unconventional ways substantially drive forward the transition to an urban space that is environmentally and socially more sustainable. Notwithstanding its potential, this study has also shown that data-driven ways to run city life are no panacea and fraught with political challenges. While digital technologies and "Smart City" may be the answer to some of today's most urgent policy challenges and largest market potentials, public and private decision-makers might constantly need to step back and ask: *what is actually the question?*

8. Contributions and outlook

8.1. Theoretical contributions

On a broader level, this study has contributed to the theoretical understanding of how digital technologies affect social interactions and governance in cities. The tentative framework proposed by this thesis conceptualizes Smart City innovation as an inherently political process that is driven by increasingly collaborative and data-driven practices in an open and flexible action net. It could be shown that concepts from science and technology studies (STS), and ANT in particular, provide a useful toolkit to explore the socio-technical phenomena that emerge from evolving human and non-human connections between people, organizations and material devices. Furthermore, it became clear that applying a primarily descriptive ANT perspective when examining ongoing change processes throughout society does not prevent research from addressing potentially arising political issues. Especially when combined with a material variation of practice theory, empirically grounded descriptions allowed to identify concrete practices which can form the basis for a structured discussion of political concerns and conflicting values in the innovation process.

8.2. Limitations of the study

Although this study could identify a new way to understand and look at public sector innovation, further research is needed to verify its robustness and generalizability. As the findings reflect to a large extent the subjective experience of a limited number of people involved to different degrees in various initiatives, they should not be regarded to exhaustively capture the evolving phenomenon of Smart City innovation. Similarly, the study presents a temporally selective snapshot of the current dynamics in one particular municipality. To credibly extrapolate the findings, additional studies covering additional case studies in different settings and developments over longer time horizons are needed. Therefore, rather than research aiming for universal claims, this thesis should be regarded as springboard that highlights pathways for future interdisciplinary research at the intersection of politics, markets, and technology.

8.3. Suggestions for further research

The issues put forward by this thesis might spark interest in a variety of different research directions. Three trajectories regarding the deeper aspects of data-driven innovation and collaborative governance across sectors seem particularly worthwhile to explore: First, this study has indicated how multiple public values clash within Smart City innovations. In combination with previous attempts to define the broad concept of ‘public value‘ (Jörgensen & Bozeman, 2007) and to understand how competing values are prioritized in public innovations (Van Gestel et al., 2008), this thesis can inform further studies focusing on the conflict between environmental and livability values and privacy values in the digital age. Second, examining the influence of cultural factors and individual governance traditions in

either facilitating or complicating trustful collaborations between public authorities, private firms, and citizens could yield additional relevant insights on how to design effective innovation frameworks. Without speculating, it seems likely that the Copenhagen's approach to Smart City development is to some extent rooted in the Scandinavian tradition of consensus-oriented cooperation across different organizational types (Greve, 2003). Therefore, complementary studies investigating Smart City innovation in other countries and cultural traditions could clarify the nature and magnitude of such cultural impacts. Third, and digging deeper into the sociological dimensions of digitalization, the prospect of a digitally interconnected city might entail the need to reinvestigate the meaning of collaboration for society. In this context, the sociologist Richard Sennett has proposed to distinguish more explicitly between the concept of 'collaboration', which assumes that different actors work toward a commonly shared goal, and 'cooperation', which acknowledges that different actors in society may pursue fundamentally different goals but nonetheless need to reach a common agreement (Sennett, 2012; 2013). The latter conception resonates well with the findings of this study, which revealed different interests and values pursued by different actors engaged in Smart City innovation. Further research on what specific skills are necessary to enable effective cooperation among citizens, public authorities and market actors may therefore yield additional valuable insights.

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Appendices

Appendix 1 – Overview of in-depth interviews

Appendix 1. Overview of in-depth interviews (chronological order)

No.	Interviewee	Position	Organization	Date	Duration	Type
1	Frans La Cour	Project Manager	Copenhagen Solutions Lab	2017-02-15	63 min	Skype
2	Jos Van Vlerken	Project Manager	Technical & Environmental Department, Traffic Department (City of Copenhagen)	2017-02-28	75 min	Phone
3	Kelton Minor	Researcher User Experience	Copenhagen Centre for Social Data Science	2017-02-28	46 min	Skype
4	Bahar Namaki Araghi	ITS Project Manager & Coordinator for EU Horizon 2020 Project	Technical & Environmental Department, Traffic Department (City of Copenhagen)	2017-03-07	65 min	Skype
5	Ceri Woolsgrove	Policy Officer	European Cyclist Federation	2017-03-07	32 min	Skype
6	Emil Tin	Project Leader & Technology and Process Advisor Bicycle Program	Technical & Environmental Department, Traffic Department (City of Copenhagen)	2017-03-08	41 min	Phone
7	Jeremy Renton	Technology and Innovation Manager	Citelum EDF	2017-03-14	39 min	Phone
8	Anna Clark	Consultant	Trivector AB	2017-03-16	36 min	Phone
9	Thomas Dale	Project Assistant	Climate-KIC Nordics	2017-03-31	41 min	Phone
				Total	438 min	

Appendix 2 – Sample interview guide

Appendix 2. Sample interview guide

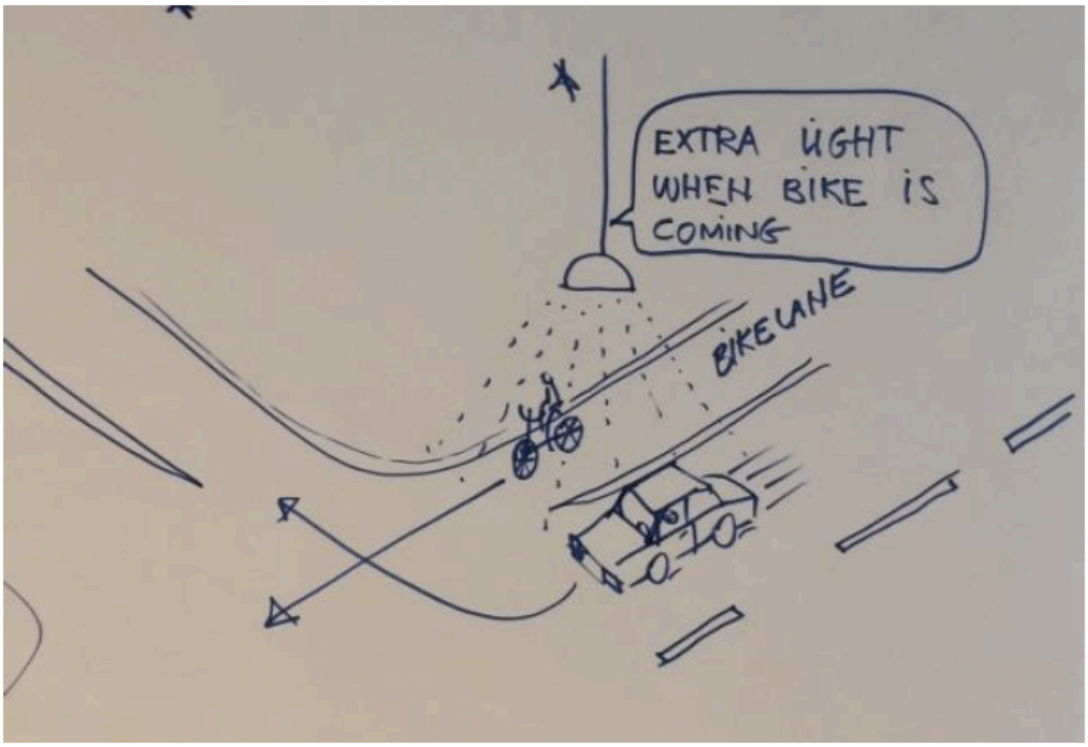
Focus area	**Sample questions**
Briefing	- Short presentation of research project - Brief outline of interview process (note taking, confidentiality, approval, structure, approximate duration)
Introduction / Warm-up	- Could you describe your role within your organization? - What activities does your role mainly entail? - Which other organizations and/or departments do you primarily work with?
Technology	- What role does technology play in your work projects? How has that changed over the last years? - How do you use/deal with data to accomplish your goals? - What technology-related difficulties do you experience?
Big Data Bicycle Challenge, innovation, and collaboration	- What was your main motivation to attend/host the workshop? - What was your main insight/impression? - How have things developed for you since the workshop? - Do you think such forms of collaborations become more common in your field? Why? Why not? - How could such collaborations be improved?
Values and concerns	- What challenges do you encounter in collaborative innovation projects? Can you give a specific example? - What experiences do you typically make when engaging with organizations form other sectors? - How do you evaluate the outcome of innovations/collaborative initiatives?
General	- What will you primarily focus on in your projects in the upcoming months? - What do you think are important future trends with regard to digital technologies/your field/public innovation projects?

Appendix 3 – Overview of main documents analyzed to select and inform the case

Appendix 3. Overview of main documents analyzed to select and inform the case

Title	Author/Organization	Published	Retrieved from
Good, Better, Best – The City of Copenhagen's Bicycle Strategy 2011-2025	Technical and Environmental Department, City of Copenhagen	2011	kk.sites.itera.dk/apps/kk_pub2/pdf/823_Bg65v7UH2t.pdf
Better Mobility in Copenhagen – ITS Action Plan 2015-2016	Technical and Environmental Department, City of Copenhagen	2014	https://www.kk.dk/sites/default/files/uploaded-files/ITS%20-%20Action%20Plan%202015-2016.pdf
City of Cyclists – Copenhagen Bicycle Life	Technical and Environmental Department, City of Copenhagen	2013	kk.sites.itera.dk/apps/kk_pub2/pdf/1135_OlhinEvp0h.pdf
Copenhagen Smart City	Kim Spiegelberg Steltzer, Copenhagen Solutions Lab	2015	http://www.almanac-project.eu/downloads/M2M_Workshop_Presentations/Session%204/Mia_Copenhagen_smart_city_2015.pdf
Copenhagen Connecting – A unique and innovative opportunity to shape the future of Copenhagen	Copenhagen Solutions Lab	2011	http://cc.cphsolutionslab.dk/_include/img/work/full/Copenhagen Connecting-UK_new.pdf
Copenhagen Climate Adaptation Plan	Miljømetropolen, Copenhagen Municipality	2011	http://en.klimatilpasning.dk/media/568851/copenhagen_adaption_plan.pdf
Denmark – Developing Opportunities for Smart City Solutions	Ministry of Foreign Affairs, Denmark		http://www.investindk.com/~/media/Files/Sheets/ICT/Smart%20City.ashx
Towards a Thriving Data-Driven Economy	European Commission	2014	https://ec.europa.eu/digital-single-market/en/towards-thriving-data-driven-economy
Data Driven Innovation. A Guide for Policymakers. Understanding and Enabling the Economic and Social Value of Data	Software and Information Industry Association (SIIA)	2013	http://archive.siia.net/index.php?option=com_docman&task=doc_view&gid=4279&Itemid=318
Horizon 2020 – Work Programme 2016-2017	European Commission	2016	http://ec.europa.eu/research/participants/portal/desktop/en/funding/reference_docs.html#h2020-work-programmes-2016-17
Bicycle Big Data in Copenhagen: Needs and Challenges (Presentation)	Emil Tin, Traffic Department (Technical and Environmental Department, City of Copenhagen)	2017	Presentation slides sent to participants after workshop
Bicycle Big Data Needs and challenges in the City of Copenhagen	Technical and Environmental Department, City of Copenhagen	2017	Document sent to participants prior to workshop

Appendix 4 – Sketch plan for intelligent street lighting system for cyclists



Appendix 4. Sketch plan for intelligent street lighting system for cyclists to increase road safety and encourage cycling in the city[1]

[1] Image taken from: City of Copenhagen (2015). *Copenhagen Smart City.* Available online: http://www.almanac-project.eu/downloads/M2M_Workshop_Presentations/Session%204/Mia_Copenhagen_smart_city_2015.pdf

Appendix 5 – Invitation to the Big Data Bicycle Challenge in Copenhagen

Dear recipient,

The Technical and Environmental Administration of the City of Copenhagen is pleased to invite you to a workshop on solutions for collecting and analysing big data for cyclists.

The Bicycle Data Workshop will take place from **09:00 to 18:00 on February 20th 2017** at the House of Innovation in Copenhagen, Halmtorvet 27. Read below for more information.

Please RSVP to Jos van Vlerken cz9y@tmf.kk.dk by Friday, February 10th 2017.

Kind regards,
Soren Bom & Jos van Vlerken
Traffic Department
Technical and Environmental Administration
City of Copenhagen

eit Climate-KIC

CITY OF COPENHAGEN