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Data Infrastructures in the Public Sector: A Critical Research Agenda Rooted in Scandinavian IS Research

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Research paper

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Abstract

Extant Information Systems research emphasizes the strategic benefits of digitalization and value co-creation for business. Less is known, however, about the dynamics of how value is co-created in the digitalization of the public sector, where data infrastructures are increasingly adopted. We identify three core empirical challenges for value co-creation in the public sphere, corresponding to the following conceptual tenets: participation in infrastructuring processes, data curation, and data protection. We propose to draw on the Participatory Design tradition that permeates the Information Systems field in Scandinavia to critically harness the political meaning of value co-creation. Drawing on a two-year project on the design of data infrastructures in three areas of the public domain (environmental monitoring, healthcare, and smart cities), we contribute to Information Systems by proposing a research agenda consisting of three future directions for critical studies of value co-creation in data infrastructures in the public sector.

Keywords: data infrastructure, public sector, critical research, Scandinavian tradition.

1 Introduction

For scholars of Information Systems (IS), the ongoing digital transformation has opened new opportunities to research how value is created and perceived in data-driven digital services, for example under the banner of Big Data and Internet of Things (IoT). Frameworks such as the Service-Dominant Logic (Lusch and Nambisan, 2015) or design and use recombination (Henfridsson et al., 2018) are useful lenses to unpack the increasingly fluid, in-the-making, and co-created nature of value in innovation. As Henfridsson et al. (2018) argue, "value of a specific digital innovation needs to be viewed not as fixed but as fluid over time, dependent both on connections to assemblages of digital resources and on the relative engagement of individuals, firms, and bots" (ibid., 90). However, these frameworks are mainly concerned with value creation in data-driven business services, hence tend to leave questions unanswered related to the ways in which *value is co-created in data infrastructures in the public sphere*.

Today, digital services are increasingly becoming instruments of policy and governance in the public sphere through the implementation of *data infrastructures*. Data infrastructures enable the implementation, delivery, and use of digital services and broadly consist of "the institutional, physical, and digital means for storing, sharing and consuming data across networked technologies" (Kitchin, 2014, p. 32). As the most recent debates around data protection and the discrimination and bias enabled by automated decision-making have shown, data infrastructures carry personal, social, and political value (Schou and Hjelholt, 2019; see e.g. Schultze et al., 2018; Vassilakopoulou et al., 2018).

The aim of this paper is to *propose a critical research agenda for data infrastructures studies*, particularly focusing on the public sector. By public sector, we mean the economic area concerned with delivering goods and governmental services to the public. By *critical*, we mean a perspective that problematizes the contradictory nature of practices, and questions deep-seated assumptions and the status quo (Orlikowski and Baroudi, 1991). Our aim is to sensitize IS scholars to make sense of the holistic nature of value co-creation in data infrastructures. Our interest in the public sector is justified by the current rush towards the digitalization of governmental services and public services (Ylinen and Pekkola, 2018). Many public sector organizations in different countries – including Scandinavia – are undergoing process of digitalization which require the establishment of data infrastructures in domains such as smart cities (Fitzgerald, 2016), welfare (Schou and Hjelholt, 2019), healthcare (Bygstad and Hanseth, 2016) and eHealth (Aanestad et al., 2017). Data infrastructures are necessary for enabling data flow across units, data analytics, and hence informing decision-making. These processes are complex and convoluted facing several challenges related to issues of, e.g., transparency, governance, and regulations. Specifically, in this paper, we promote an empirically based and theoretically informed understanding that problematizes how decision-making practices co-evolve with data infrastructures and that unpacks how value is (co-)created within those practices. We build on the results from a two-years research project that studied the sociotechnical aspects associated with the adoption of IoT solutions in the public sector in Norway. Based on an analysis of the extant literature on data infrastructures and a cross-case analysis of our empirical data, we identify three emerging core issues related to value co-creation in data infrastructure in the public sector. These aspects are related to the participation of different stakeholders, the importance of considering the mundane work of data curation in data infrastructure design and policy, and the ethical inplications of data protection.

Our proposed perspective subscribes to a long-established sociotechnical approach to studies of information infrastructure inclusive of arrangements of systems, people, standards, and data management practices and algorithms (Ciborra, 2000; see e.g. Hanseth et al., 1996; Ribes and Finholt, 2009). Our emphasis on data rather than information infrastructures is intended to stress the central role of data and the often-invisible practices of data work (Leonelli, 2014). We foreground data and data work to think about data not as a finished product, or a commodity, but as a *central and evolving concern* for different stakeholders in service-based innovation. This perspective on data is in line with Jones' (2019) recent argument that we should be more sensitive to how "data are partial and contingent and are brought into being through situated practices of conceptualization, recording and use" (p. 3). In this sense, value is shaped over time through the way data are (co-)constructed and evolve in infrastructures by balancing heterogeneous concerns. Our argument draws on a performative perspective according to which data infrastructures are not neutral calculative devices, but they shape what matters as relevant information, relevant participants, and relevant publics (Bowker and Star, 1999). Accordingly, data infrastructures enact specific realities by filtering what can be seen and by creating novel ways of perceiving the world, and new visibilities and invisibilities (Jensen and Winthereik, 2013). In our approach, we take inspiration from fields such as Computer Supported Cooperative Work (CSCW) and Science and Technology Studies (STS), inspired by the philosophy of science (Kitchin, 2014; Leonelli et al., 2017).

This transdisciplinary and performative stance in IS owes much to the Scandinavian tradition in Participatory Design (PD), which deeply shaped IS research in Northern Europe. As such, we use this opportunity to state that a critical approach to innovation in data infrastructures is not new to IS but sits comfortably in the political sensitivity of Scandinavian research in computing (Parmiggiani and Karasti, 2018; Roland et al., 2017). Our research agenda draws upon and contributes to the Scandinavian tradition for the study of data infrastructures for the public. Accordingly, we present a conceptual framework to address the identified core issues for data infrastructure research that consists of three conceptual tenets informed by the PD literature: participation, data curation, and data protection.

The remaining of the paper is organized as follows: in the next section, we briefly review the literature on data infrastructures in the public sector and identify three core issues for a value-perspective on data infrastructures. Afterwards, we introduce a critical and transdisciplinary theoretical lens on data

infrastructure studies, based on a Scandinavian perspective. Next, we present and briefly cross-analyze our empirical studies in three areas of the public sector. Finally, we present a critical research agenda as a set of recommendations for future research on data infrastructures in IS based on our theoretical framework. We conclude by summarizing our argument.

1.1 Data infrastructures in the public sector

The utilization of digital data is currently recognized as a critical asset in the public sector, and it is fueling the emergence of automated smart services. For instance, by embedding distributed IoT sensor networks into public spaces, vast amounts of datasets are generated (Dohler et al., 2013). Advanced algorithms make it possible to analyze and visualize these environments in novel ways, and through this enable new forms of decision-making and intervention (Dourish, 2016). In the remainder of this section, we briefly describe three demands related to how value emerges from decision-making and interventions in public sector infrastructure, and that are not usually considered salient in commercial or corporate data infrastructures.

Research has identified the transparency of data flows as one main issue. While certainly being a marketing opportunity for private corporation despite the public service façade, the opaque nature of communication in IoT networks is difficult to grasp for citizens (ibid.). As some scholars have observed, technological arrangements such as the IoT come with significant implications in terms of ethics and professional knowledge required to operate them, despite initial promises of transparency and ease of use (van Deursen and Mossberger, 2018). In addition, there is an increasing awareness of the risks associated with forms of technocratic understanding of data infrastructures which assume that complex societal problems can be treated as technical problems and addressed by technical solutions (Janssen and Kuk, 2016). For example, critiques are raised against the automation of clinical judgements, important ethical questions are raised in the use of predictive analytics (e.g., predictive profiling, predictive policing, Waardenburg et al., 2018), and reports advert against the potential to encode discrimination in automated decisions (The White House, 2016).

Moreover, research has pointed out that in the public sector, data infrastructures lack a single governance authority and instead emerge through the negotiating of a range of different parties (Vassilakopoulou et al., 2017). For example, infrastructures for the delivery of healthcare services in the home or the personal devices of citizens and patients depend on massively distributed data points. This poses different challenges in terms of regulation and control than previous infrastructures, which often utilized more centralized data sources (e.g., registries) and enabled centralized forms of decision-making and governance (Larkin, 2013). In addition, this is also problematic for robustness. For instance, shared and robust data infrastructures are critical in healthcare, as data inaccuracy, incompleteness, and inconsistency could trigger medical errors during the course of care, and hinder further analysis from monitoring and research purposes (Liaw et al., 2013). Due to their heterogenous installed base, data infrastructures in healthcare have proven to be challenging to design, build, maintain and change (Aanestad and Jensen, 2011; Grisot and Vassilakopoulou, 2017; e.g., Hanseth et al., 2006).

Finally, infrastructures can serve as political instruments in the public sector. Research has observed that data infrastructures in eScience might become a regulatory technology, or an interface through which heterogenous stakeholders such as researchers, funding bodies, and the policy makers instantiate their relations (Kaltenbrunner, 2017). Public policy makers such as the European Union tend to propose techno-centric definitions of research data infrastructures that become instrumental to integrating the various national research systems in Europe on the both the institutional and scientific level (ibid.). Data infrastructures for eScience and other domains can hence serve high-level political goals. This often introduces, however, a tension between the actual data curation practices and the frameworks promoted by governments: “What policymakers need and what scientists find interesting are often too different - or, to put it in another way, a yawning gap of ontology and standards separates the two” (Edwards et al. 2013, 10).

1.2 A value view on data infrastructures: core issues

The characteristics of data infrastructures in the public sector that we reviewed above all point to a faceted and evolving perception of the value associated digital services that goes beyond conceptions rooted in business and economics, towards a need to address social challenges in more holistic ways (Jetzek et al., 2014). We therefore follow Barrett et al. (2016) in conceptualizing value as dynamic, fluid, and co-created through the alignment of heterogeneous actors, their interests, and social and material aspects. In this sense, value is relative and emergent, i.e. data infrastructures generate multiple types of value for different stakeholders over time (ibid.). Based on our reading of the literature, we identified three central aspects that challenge our understanding of how value emerges for decision-making in data infrastructures in the public sector.

First, the exponential amount of data produced by ubiquitous devices (e.g., IoT) challenges our understanding of participation in data and knowledge creation and use. Much attention has been paid to the volume and velocity of the Big Data available in modern infrastructures. As a result, data-driven science has been proposed as the alternative to knowledge work (Kitchin, 2014). We believe that the value of (big) data infrastructures rather lies in the epistemological consequences of participating in working and knowing with the data (ibid; Monteiro et al., 2018). The commodification of data, however, is producing a logic of accumulation that concentrates new means of knowing and new phenomena in the hands of powerful actors – what Zuboff (2019) calls "surveillance capitalism". Everyday data, for example about health or behavior, are becoming part of opaque commercialization strategies (Constantiou and Kallinikos, 2015) by private companies which are involved by public agencies in handling personal and sensitive data as providers of services in the public sector.

*Second, the importance of data curation needs to be recognized***.** boyd and Crawford (2012) observe that 'big' data are characterized by "the widespread belief that large data sets offer a higher form of intelligence and knowledge that can generate insights that were previously impossible, with the aura of truth, objectivity, and accuracy" (ibid., p. 663). Despite the availability of smart and interconnected technologies, still the biggest challenge for governments is collecting the data, as they not only come from multiple channels (such as social networks, the Web, and crowdsourcing) but from different sources (such as countries, institutions, agencies, and departments) (Kim et al., 2014). Leonelli (2014) argues that the value of approaches based on Big Data analytics (e.g. for eScience) does not lie in the vastity of the data involved but rather emerges from "(1) the prominence and status acquired by data as commodity and recognized output, both within and outside of the scientific community and (2) the methods, infrastructures, technologies, skills and knowledge developed to handle data" (ibid., p. 1). Accordingly, despite technologically enthusiastic calls for the "end of theory" (Anderson, 2008), empirical studies in healthcare and eScience point to the crucial importance of data curation, i.e. the daily practices of maintaining, sharing, accessing, and reusing the data over the long term. These analyses recognize the relative nature of the value of data, as these only make sense within specific socio-material assemblages of instruments, norms, conceptual scaffoldings, community interests, and practices (Edwards et al., 2013). Ultimately, data value is subject to very mundane and institutional constraints associated to funding structures and data management and integration over time (Cohn, 2016).

Third, the implications of data infrastructures for data protection and privacy should be further problematized. Following from the previous point, the sharing of data is also a crucial yet underestimated issue. The flip-side of the silo-ed nature of data infrastructures has to do with personal data management. In this sense, the value of data acquires also an ethical dimension associated with the data about oneself becoming that person's personal property, but the boundaries for data protection and privacy are not yet fully established. Indeed, "Big Data presents a new set of privacy concerns in diverse areas such as health, government, intelligence, and consumer data" (Ekbia et al., 2015, p. 1536). In particular, when private companies develop data infrastructures, often on behalf of local or national or supra-national governments, there is a need to ensure that the vulnerabilities of personal data are minimized and that citizens are allowed to access the data about themselves in an intuitive way (Ng and Wakenshaw, 2017).

In sum, what these challenges demonstrate is that the emergence of value in data infrastructures is always a political process. Apparently conveying ideologies of neutral and value-free knowledge production, data infrastructures embody political agenda-setting aims (Monteiro and Parmiggiani, 2019). The ongoing debate about climate change is a clear example of the political nature of data. On the one hand, the same data are used to either confirm or deny global warming (Conway and Oreskes, 2012). On the other hand, data infrastructure for global climate monitoring also shape "political discourse in ways that conflicted local, regional, and national knowledge" (Edwards et al., 2013, p. 10): while data infrastructures are increasingly being set up to produce 'global' knowledge, they environmental knowledge that is needed for policymakers to act is regional and culturally specific.

2 Theoretical background: Toward a critical lens onto data infrastructures from a Scandinavian perspective

The IS literature has highlighted several challenges associated with the design and implementation of infrastructures, as well as developed theories that describe their transformation (Henfridsson et al., 2018; Lusch and Nambisan, 2015). The spectrum of contributions is broad, from supporting managerial decision-making (Sharma et al., 2014) to providing in-depth empirical analysis of data-centric work practices in infrastructure (Ribes and Finholt, 2009). In so doing, the IS literature has been explicit on the ontological differences between digitization and digitalization. While 'digitization' is defined by dictionaries as the process of converting analog information into a bit stream, 'digitalization' is the "sociotechnical process of applying digitizing techniques to broader social and institutional contexts that render digital technologies infrastructural" (Tilson et al., 2010, p. 750). In this paper, we subscribe to a *performative* understanding of digitalization processes: infrastructure is a sociotechnical assemblage that emerges only in relation to practice and is productive of specific realities (Star and Ruhleder, 1996). Visualizations displayed in e.g. dashboards or other tools should therefore not be approached as mirror images of an environment, but as *algorithmic phenomena*, namely situations that are brought about by and make sense within specific material-discursive practices (Orlikowski and Scott, 2015). From this point of view, the way a phenomenon (including a dataset) is enacted are rhetorical hence have political meaning (Monteiro and Parmiggiani, 2019).

Given the ongoing widespread application of data infrastructure for digital service delivery and decision-making in the public sector, we believe that a systematic *critical* stance towards the study of value co-creation in data infrastructures is needed to unpack its political meaning and consequences. Scandinavian IS research has the potential to contribute their theoretical and empirical sensitivity to fill this gap (Bygstad et al., 2017). In what follows, we highlight a first conceptual framework to promote a critical lens on data infrastructures inspired by core ideas of the Scandinavian tradition in Information Systems and Participatory Design (PD).

Born in Scandinavia in the 1970s, PD relied on the fluid collaboration between researchers, workers, and trade unions to ensure end users where actively involved in the design of work-oriented ICT solutions. Rather than a technical aim, these early efforts promoted a political agenda with a democratic ideal. Scholars of PD attempted to include and translate the skills, interests, and experiences of users (e.g., workers) into technology design and implementation (Simonsen and Robertson, 2013). Although PD has evolved heterogeneously in different contexts, its political sensitivity is still at the heart of the Scandinavian approach in IS and one of its most distinctive traits, reminding us that design is always biased because of political and ethical concerns[1] (Bjerknes and Bratteteig, 1995; Bødker and Pekkola, 2010).

[1] The highly influential work of Susan Leigh Star and Geoffrey Bowker has been crucial to let this perspective travel worldwide and bridge with, for instance, the US (Bowker and Star, 1999; Star and Bowker, 2002).

Scandinavian IS studies of infrastructure influenced by PD have, among other things, recently evolved into conceptualization of infrastructures as infrastructur*ing*, by shifting analytical attention from infrastructure as static structure, to infrastructure as a dynamic process, constantly in-the-making (Star and Bowker, 2002). Behind the lexical shift is a gestalt shift (Bowker and Star, 1999), an attempt at foregrounding the ongoing, often mundane, *work* of maintaining, repairing and upgrading sociotechnical assemblages (Karasti et al., 2018). Such a process view is relevant for a critical perspective onto data infrastructures. It exposes how an infrastructure and their political connotations comes into existence in relation to organized "technical, material and knowledge interventions", also called infrastructural work (Bowker and Star, 1999), or data work (Bossen et al., 2016; Pine et al., 2018). Recently, this stream of research highlighted that the IoT, intelligent algorithms, and real-time data flow pose challenges to conceptualizations of the politics of infrastructuring in terms of user empowerment and participation in technology development (Parmiggiani and Karasti, 2018). These challenges strongly resonate with the ones addressed by the Scandinavian scholars in the 1970s, although at a larger scale (ibid.).

Bringing a PD-rooted, Scandinavian approach into the understanding of data infrastructures aims to reinvigorate the intrinsically critical orientation of the IS field, towards constructive political controversy and contestation at the societal level. In particular, we would like pinpoint three conceptual tenets that emerge from our review of the literature on data infrastructure, that are particularly significant for the public sector. These three concepts (participation; data curation; and data protection) are the among the core concepts in Scandinavian PD research, and we adopt them as dimensions to propose our research agenda for critically unpacking value creation in data infrastructures.

The first concept that emerges from our analysis of data infrastructures, particularly in the public sector, is that of *participation in infrastructuring work*. As early Scandinavian PD scholars have shown, empowerment in technology development has less to do with the design outcome per se, and more with the process of participating in knowledge production and in the negotiations of what constitutes relevant knowledge is crucial to empowerment (Kensing and Greenbaum, 2013). Although we should always be specific about technological configurations (Monteiro and Hanseth, 1996), the way different stakeholders are defined, talked about, and engaged (or not) in data and knowledge production in infrastructures should be at the center of today's IS agenda. In other words, patterns of dominance in technology development and use still deserve to be challenged (Beck, 2002). For instance, Roland et al. (2017) demonstrate how the design of the architecture of a digital platform of healthcare services in developing countries deeply shapes the nature of participation.

In problematizing the notion of participation, PD scholars have been sensitive to the importance of including *data curators* and their knowledge in design processes. Data work is a crucial yet underestimated dimension of infrastructuring work. A strand of research, also outside Scandinavia (Jackson, 2014), has strived to make this type of mundane visible in their analysis and storytelling. For example, Karasti and colleagues (2006) illustrate how data work – the daily practices of collecting, storing, and preparing the data – is central for sustaining data infrastructures over the long term. Similarly, in the healthcare field, CSCW researchers have discussed how novel forms of data work are requiring more time, development of new competences and skills, and creation of new functions and roles for professionals and patients alike (see the special issue on "Data Work in Healthcare" in the Health Informatics Journal, 2019). "Medical scribes" for instance emerged as a new data-work occupation in response to increased demands for documentation and digitalization in healthcare (Bossen et al., 2019).

Finally, data curation has also an ethical dimension related to *data protection*, especially relevant as a large part of welfare services are today provided via digital platforms. In the last three decades, Scandinavian PD scholars have in fact shown how overly technological accounts of infrastructure fail to highlight the consequences of technology for data privacy and security. For example, Kyng (2010) identifies intellectual property rights as a central concern for the Scandinavian IS research influenced by PD. Outside Scandinavia but drawing on the Scandinavian PD/IS tradition, Clement et al. (2012; cf. Shapiro, 2005) remark that PD insights should be brought to bear more systematically on large-scale (data) infrastructures in the public sector. In the public sector, the authors point out, data infra-

structures "have largely been built on the same principles as those of large private sector global enterprises, and unobtrusively embed and reinforce a host of political/economic/cultural assumptions that shape our daily experiences and live chances" (Clement et al. 2012, 22). From this starting point, the authors identify data privacy and security in particular as one central risk for data infrastructure development. In line of the conceptual background of this paper, they propose using the concept of infrastructuring as a sensitizing lens to make these issues more visible and engaging with political movements that can influence data infrastructure design and development.

3 Case context and research methods

This paper is based on the results from a two-year research project (2017-2018) funded by the Norwegian Research Council. The project examined sociotechnical aspects associated with the adoption of IoT solutions for public governance. Within the frame of the project, we conducted an embedded case study (Yin, 2009) in three different areas in the public sector: environmental monitoring infrastructures (sometimes under the umbrella of eScience), healthcare services for remote care (or eHealth), and Smart Cities.

The cases were chosen strategically for being *paradigmatic* examples of the political consequences of data infrastructure for society (Flyvbjerg, 2006) as explained in Section 1. Data collection in the three cases was conducted over a period of two years with an ethnographically inspired method, qualitative data from interviews, observations of work and document analysis (e.g. project documents, press releases, official strategy documents). Research detailing the case studies and the findings has been published elsewhere for each case (Grisot et al., 2018). In this paper, we use the cases as illustrations of applications of data infrastructures in the public sector to show the evidence from which we have drawn three main 'lessons learned' in form of a research agenda. To identify the research agenda that we present in Section 5, data analysis was carried out through an inductive-deductive strategy. In the first phase, we open-coded the data following Emerson et al.'s (2011) guidelines for coding ethnographic data within each case. Initially an inductive process, in the second phase our codes were gradually refined and clustered first separately by the two authors, then jointly by organizing half-day or full-day intensive data analysis sessions. In these sessions we identified the common themes across the cases with specific attention to aspects that were most relevant for the public sector context. In the second phase, to evaluate the novelty of the emergent findings, we reviewed the IS literature, hence including a more deductive approach. We made sure to include contributions addressing data infrastructures under other labels, such as information infrastructure and digital platform (ecosystem), where the latter can be understood as infrastructures under given analytical conditions (see Plantin et al., 2018 for additional details). As we did so, we realized that our codes resonated with notions and debates within the Scandinavian tradition in IS particularly influenced by its political roots in Participatory Design (PD). Our data revealed for example that, although often talked about as a technical or modelling issue, the design and implementation of data infrastructures often foregrounds political aspects associated with the dynamics of control and inclusion/exclusion of the involved stakeholders. Our analysis pointed to the need for a more politically informed, critical perspective on data infrastructures in IS. In the third phase, we confronted our clusters with the literature and identified areas in IS research with a strong potential for critical studies of data infrastructures. The result of this analysis was the recommendations of data curation, participation, and data protection.

4 Applications of data infrastructures in the public sector

4.1 Environmental monitoring domain

The adoption of publicly funded distributed data infrastructures to support the environmental sciences is not new *per se*. Science has traditionally dealt with challenges of handling big data, or large volume of data in complex research experiments, including climate science (Edwards, 2010), environmental

monitoring in the Arctic (Baker et al., 2016), and biology (Leonelli, 2014). The commodification of data and sensor networks, however, is currently motivating efforts to establish distributed (e.g., trans-national), cross-disciplinary standardized data sharing infrastructures or digital platforms by national and international regulatory bodies. While environmental monitoring and modelling has traditionally been a slow and situated practice (although highly collaborative), these initiatives aim to transform environmental monitoring into a (near-) real-time and integrated practice (Parmiggiani, 2015).

The case study conducted in our project focused on the design and maintenance of IoT-based data infrastructure for environmental monitoring in Europe and particularly in Norway. The infrastructure we have studied is part of the international long-term ecological research network (ILTER)[2], of which Norway LTER is one node. We have focused primarily on two complementary analytical levels: first, on the level of policy-making, by following the European Union's initiatives to adopt top-down, regulatory approaches to handle and standardize the different environmental monitoring traditions across countries, to establish a pan-European research infrastructure (Parmiggiani et al., 2018). Second, we looked at the situated data management practices taking place at environmental monitoring stations in Norway that are part of the ILTER network.

Environmental monitoring stations are very heterogeneous, also within the same country. They are characterized by different objects of interest (e.g., terrestrial, fresh/salt-water, or air species), funding structures, and data management tradition. We observed that the implementation and maintenance of networks of IoT infrastructures for long-term environmental monitoring (such as ILTER) consist on carefully balancing the integration of systems and people to ensure fluid data sharing on the one hand, and the need to account for locally tailored routines, on the other hand. Specifically, while studying the local routines to collect and share the environmental data, we became aware that the work to ensure environmental data quality (data curation) crucially depends on the often unacknowledged and invisible work and local adaptations and workarounds that environmental scientists conduct (Baker and Karasti, 2018).

At the same time, our study has found that data infrastructures for the science can also serve high-level political goals, particularly as part of the EU's constant efforts at integrating science and policy in the continent. This often introduces, however, a tension between value that environmental data acquire during the technical and scientific data curation practices, on the one hand, and as policy instruments inside the frameworks promoted by governments, on the other hand. As we have explained elsewhere, the dependencies that emerge as part of the situated adaptations, and the participation of scientists in handling them, are underrepresented and under-funded in policy-making efforts by public authorities such as the EU (Parmiggiani et al., 2018). In this tension, we found that the local practices and interests tend to be forgotten. Many of the environmental researchers which whom we interacted are aware of this lack of recognition, and voiced concerns related to intellectual property rights. In particular, they were often left unsure whether sharing data on a centralized, pan-European digital infrastructure would allow other researchers to use their data without properly citing them, hence not recognizing the amount of work that they put in generating and cleaning the data.

4.2 Healthcare domain (eHealth)

The emergence of large-scale data infrastructures in healthcare has enabled the use of health data for a range of novel purposes related to data-driven management, accountability, and performance resource management as well as providing a new source and foundation for healthcare and medical research data. The case conducted in the project has focused on the design and building of a data infrastructure for data sourced from personal digital devices in the context of a remote care service in primary care in Norway. The data are generated at home by patients affected by chronic conditions such as diabetes,

[2] See for instance www.ilter-edu

heart disease and COPD, and multi-morbidities. The devices used are for instance digital scale, thermometer, spirometer. The devices are connected to a system for remote care to which both patients and nurses have access. The nurses, sitting in a primary care center, access the data, evaluate the patients' situation and follow up mainly via text messages. For instance, if the data report increasing body temperature on a COPD patient, nurses would tell her to start taking antibiotics before a full infection develops.

In our study we have focused on two main analytical levels: first on how nurses and patient interact through data and how data enable new forms of care and of nurse-patient interaction; second, on the systemic level by looking at the use of the data beyond the remote care center. Our focus on the patient-nurse interaction has shown the novel practices of data generation by patients, and how patients need to learn to produce the data nurses need (Grisot et al., 2019). Nurses deal with a large amount of very specific data, and they need not only to sort out the most meaningful data, but also to direct patient attention to those data that are actually showing the critical correlations (e.g. between temperature and body weight). The quality of the produced data has also shown to be an important issue, and patients need to learn how to position and take care of the devices at home (without help from the nurses). Thus, tasks that are traditionally performed by nurses (e.g. taking temperature), are now delegated to patients. In addition, nurses' tasks are also transformed. We observed the data work of nurses and their need to develop novel analytic skills (Grisot et al., 2019).

Our focus on the systemic level, has foregrounded issues related to data flow. For instance, nurses in municipal health services have the duty to document their interactions with patient in the Electronic Medical Record (EMR). However, with the use of digital devices in remote care, nurses are continuously receiving data. Thus, there need to be filters in place for instance to decide if data should be documented in the EMR every time a new data instance is reported by patients, or on a daily basis, or less often. Also, there need to be routines in place about who is supposed to take decision and action based on the data from the devices. For instance, an ongoing discussion in the case has been about the role of General Practitioners and if and how they should have access to data.

4.3 Smart cities and city governance

Data infrastructures for city governance instrument cities with digital devices that produce data. These can then enable real-time analysis of city life, and new modes of urban governance. The aim is to provide the raw data resulting in more efficient, sustainable, productive, open and transparent cities. In our case we have conducted a study on the design of a city dashboard in the municipality of Oslo. The dashboard is expected to provide insights and basis for optimal decision making through key figures, KPIs, predictions and real-time data from different segments in a city or community. The municipality has developed a pilot project to demonstrate the potentials of using technology in a Smart City context. The prototype visualizes climate and environmental data, such as bicycle and pedestrian counts, use of charging stations for electrical vehicles and air quality. The data is shown in real time. Historical data is analyzed and combined with weather data. In this way it is possible to present predicted data based on machine learning. As the pilot was in the planning phase, our research has mainly been focused on the discourse around the city dashboard.

Our findings show that stakeholders are concerned about how data will be combined. Part of the vision is to make new connections between different data sources by cross-analyzing data from sensors in different domains. This would imply breaking the data silos across sectors and provide instead a solution which is domain agnostic and allows to 'plug and play' different sets of sensors devices. For example, the dashboard will support the visualization of weather data and air quality data. However, it is not clear yet what type of inferences will be made, and which decisions will they inform in the context of city governance.

	Data curation	**Participation**	**Data protection**
Environmental monitoring	Environmental researchers engage in data work, or data curation, to ensure that data are both globally and locally meaningful.	The work of environmental researchers to ensure data quality is crucial for distributed data infrastructures yet underrepresented in policies.	Issues of intellectual property rights are crucial in the sharing and reuse of data produced by environmental researchers.
eHealth	Nurses in remote care engage in 'data work': sorting out relevant data, making sure patients learn to use the digital devices properly and produce quality data.	Patients generate data and have access to data visualizations. This requires the development of analytics skills. Patients also learn about causalities: how their behavior affects the measured data values.	The data infrastructure is highly regulated. Patients cannot plug in their own private devices.
Smart Cities	Quality and calibration of sensors is a core issue. Sensors produce large amount of data which need to be filtered and sorted out to be meaningful	Citizens can become data producers (by use of own local sensors) or secondary use of data if these are made accessible (open data).	Issue of privacy are highly relevant. Sensors in urban and natural environment raise issue of surveillance and personal privacy.

Table 1. Cross-case analysis, showing how each empirical case we addressed (environmental monitoring, eHealth, and Smart Cities) can illustrate the concepts we derived from the literature (data curation, participation, data protection).

5 Agenda for IS research: On being specific about Politics in Data Infrastructures

Each case illustrated in Section 4 shows a slightly different understanding of data (see table 1). In our analysis, we portrayed how data come to be with reference to specific practices of data curation, participation, or protection, hence illustrating the emergent, performed, and co-created nature of value in data infrastructures. This paper does not claim to be exhaustive but pursues a programmatic agenda. It aims to bring forth a critical approach to sensitize IS researchers towards problematizing the political meaning associated with these practices in data infrastructures. Following from our analysis, we argue that IS research should critically question the way value co-creation and politics intertwine in data infrastructures. In Section 2 we developed an initial theoretical framework consisting of three conceptual tenets inspired by the Scandinavian PD tradition (participation; data curation; data protection). We now present four possible research directions for future IS research on data infrastructures, each related to one of the three concepts we identified. For every research direction, we list several research questions that could guide the analysis.

5.1 Critically examine the daily practices of data curation in data infrastructures

Our cross-case analysis illustrates some aspects of the sophisticated, multi-faceted yet often forgotten ways to maintain, disseminate, and share the data. Turning data into information and knowledge – i.e. making sense of data – has become a pressing need in our society at all levels. The amount of data available has grown hugely and digitization has made the accumulation, visualization, and analysis of data easier. However, the overarching importance of data curation practices tends to be overlooked by researchers and policy makers. At least two opportunities follow from this observation. First, understanding infrastructures as performative of algorithmic phenomena helps us realize that data never ex-

ist independent of their use and are necessarily constructed (Jones, 2019). As a result, future IS research should develop a more systematic approach to make visible and conceptualize the work to scaffold the data.

Hence, research questions to guide researchers are: *How do designers of a new data infrastructure investigate data management practices in a field? What types of practices and work are talked about in data infrastructure design? How are they formally included in system architecture and governance?*

Second, our analysis shows that data curation takes heterogeneous shapes and is always context-dependent. Data work does not only consist of 'working on data' (e.g. producing new data in accounting for and recording the work done) but also 'working by data', as work intensively relies on data. Accordingly, new occupations emerge requiring specific competences for data work, as the example of data-driven remote care conducted by nurses illustrates. This aspect points to a need to further analyze the consequent redistribution of work, time, resources, authority, responsibilities and power that follow suit.

Therefore, possible research questions to guide researchers are, for example: *What are the new competences, tasks, and functions that the emergence of data-driven services entails? How are existing occupations and professions changing in the wake of the push for data-driven services? What are the emerging data occupations?*

5.2 Critically question participation in data infrastructures

Zuboff (2015) observed that the accumulation of data produced by digital infrastructures introduces new mechanisms of information extraction and control to quantify people and their behavior, which are difficult if not impossible to understand or even expect for those who do not have the knowledge and the financial capacity to be part of emerging digital data infrastructures. Attending to infrastructuring is an entry to exploring how reality is practically constituted (Karasti and Blomberg, 2018): by forming some relations, other possible relations are excluded, by making the world available for some interventions, other possible interventions are left out. This theme speaks to the early political roots of the Scandinavian tradition in PD (cf. Beck, 2002): who participates in value (co-)creation? For example, our informants in the environmental monitoring case were concerned that their voice was not heard on the policy making level. Future research in IS should therefore develop an analytical apparatus to trace which voices are listened to, included, and which are instead marginalized or left out, in infrastructuring processes.

A facet of this theme is related to openness. Despite the promises of digital data infrastructures to be transparent and open up participation and knowledge sharing, scholars have begun to observe a dangerous tendency, where the control of data infrastructures falls in the hands of an oligarchy of powerful stakeholders, also in the public sector (Ruppert, 2015). This is problematic from a PD perspective, as control over the infrastructuring processes crucially implies control over the means of knowledge creation (Parmiggiani and Karasti, 2018). Recently, the debate on eScience has also focused on the open access to the digital output of scientific research, namely, the articles published by researchers in conference proceedings and journals. However, the core problem is about having access to and being acknowledged for the input of research – the raw research data (Arzberger et al., 2004), despite the availability of inexpensive cloud-based data sharing solutions.

Possible research questions that researchers might ask are, for example: *How and why is (data) work considered (in)visible and/or (ir)relevant? How are stakeholders and participants defined as such in data infrastructure projects? How are they talked about? How are they included longitudinally in infrastructuring processes? What categories are defined, included/excluded, and why? How do categories, classifications and algorithms shape design processes and what counts as data, and what do these schemes make visible and invisible? How are infrastructures configured and how do they shape the processes of knowledge production?*

5.3 Critically examine the relation between data infrastructures and data protection

The recent Facebook/Cambridge Analytica scandal has opened the Pandora's Box of the ethical implications of sharing data with private corporations whose business models are centered on commodifying user behavior data for, e.g., programmatic advertising (Zuboff, 2019). These corporations are often involved with their data infrastructures in Smart Cities projects heralded by the public sector, but it is arduous to trace what data are shared, how, and with whom. Data infrastructure policy making clearly illustrates that not all national and supranational governments are aligned in dealing with personal data protection regulations. For instance, the USA, the EU, and the various European countries have very different approaches and traditions, yet data infrastructures are often transnational. However, researchers often tend to forget the policy context in which public infrastructures grow and thrive. Future research on data infrastructures should further delve into and problematize the role of regulatory bodies, governments, and political traditions in the way data are managed and conceptualized.

Research questions that might be asked are: *What does it involve being enrolled or engaged in the generation, distribution, understanding of data on one's private sphere, and have such data come back to you filtered and interpreted by other parties that base interventions for you on those data?*

Moreover, if we look at the issue of data privacy through an infrastructuring lens, we might see that protecting data from mishandling and disruption is the flip-side of an epistemic focus on protecting data reliability and reusability in infrastructure (cf. Tempini and Leonelli, 2018) – a concern that was voiced by our informants in the environmental monitoring case.

Additional research questions that researchers might ask are, therefore: *What instances of reflection, management and accountability are created with specific data infrastructures? What challenges, conflicts, and opportunities emerge? How do the agendas of data for accountability and secondary uses influence and become integrated into systems design and development? Is this a simple add-on, or a dominant concern?*

6 Conclusions

A growing research stream on data infrastructures in IS emphasizes the strategic benefits of digitalization on several levels. Little is known, however, about the emergence data infrastructures in the public sector and specifically about how value is co-created by different stakeholders from the data. In this programmatic paper, we proposed an initial research agenda toward critical data infrastructure studies in the public sector. We did so by drawing on calls to reinvigorate the political orientation to IS research that is at the heart of Scandinavian scholarship. Our review of the literature by no means claims to be exhaustive but wants to open up a conversation on the nature, underlying assumptions, current challenges, and possible ways forward of data infrastructures in the public sector. By proposing several guiding research questions, we invite future research on data infrastructure in IS to critically assess (1) the daily and heterogeneous practices of data curation that scaffold infrastructures; (2) the way participation unfolds in data infrastructure projects; and (3) the consequences of data infrastructure for data protection.

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