Smart Cities: Urban Governance in the Data-Driven Society

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Abstract The vision of a smart city that uses digital technology and big data to improve urban life has received a lot of attention, both from academia, business and government. While praised by some, it is also a vision that has been criticized for being vague and dominated by a top-down approach. This study examines data-driven practices in the five largest Dutch municipalities to gain a better understanding of smart city's logics and to identify mitigation strategies for its issues. It does so by applying a socio-technical framework. The findings show that data-driven practices operated according to three different logics: entrepreneurialism, managerialism and communitarianism. Moreover, it appeared crucial to look beyond just concerns about corporate power and privacy for fully grasping the downsides of data-driven practices. A broad distinction could be made between technical-methodological and ethical-societal issues. Finally, a wide range of mitigation strategies was observed to safeguard public interests against these issues. The interrelationships that were encountered between technology, social actors and institutional properties ultimately demonstrate the importance of taking a socio-technical perspective to understanding smart cities.

Keywords Smart city · Big data · Internet of Things · Urban governance · Socio-technical framework

Introduction

All over the world, local governments strive for smarter policies on problems as diverse as crime, climate change and unhealthy lifestyles. Companies and knowledge centers (e.g. universities) also invest their time and money in what has been dubbed the smart city (Townsend, 2014). This upcoming buzzword typically refers to the use of digital technologies and data for urban governance, resembling the use of 'smart' in smartphone, with the promise of providing solutions to major societal challenges (Kitchin, 2014b).

Still, there is no consensus in the literature about what makes a city smart (Meijer & Bolívar, 2016). Some researchers use the term interchangeably with the innovation-focused creative city (Albino, Berardi & Dangelico, 2015) or the sustainability-focused green city (Antrobus, 2011). Education and urban greening could therefore be deemed smart policies just as well. In fact, the term is often used in city benchmarking to indicate the sum of many positively regarded aspects of urban life (Caragliu, Del Bo & Nijkamp, 2011). Some critical scholars dismiss the smart city as just another marketing label for entrepreneurial modes of urban governance (Söderström, Paasche & Klauser, 2014), while others praise its potential for improving ecological sustainability and quality of urban life (Hashem et al., 2016; Pan et al., 2013).

This paper focuses on the entanglement of urban governance and digitalization as central to smart cities. It does so by making an analysis of data-driven practices in the five largest Dutch cities: Amsterdam, Rotterdam, The Hague, Utrecht and Eindhoven. Previous research in the Netherlands shows that ICT and data are considered the most important aspects of a smart city by municipality officials (De Wijs, Witte, De Klerk & Geertman, (2017). The concept of smart city is therefore broadly defined as an urban vision that promotes the use of digital technologies and data for achieving more insight and grip on all sorts of economic, social and environmental problems (Manville et al., 2014; Van Zoonen, 2016). Empirical research about how this works out in practice is relatively scarce though (Kitchin, 2015), which is why the underlying motivations or logics for developing a smart city remain unclear and underdeveloped.

Several researchers criticize the smart city vision for lacking a connection to the actual desires and interests of ordinary residents (Greenfield, 2013; Hollands, 2008; Kitchin, 2014b; Townsend, 2014). Data-driven practices would often be dominated by a top-down approach that on the one hand favors corporate power over citizen power (Söderström et al., 2014), and on the other hand risks subjugating urbanites to mass surveillance and control (Krivý, 2016). Smart cities can thus not be seen separately from a number of important issues. For instance, the virtual connecting of many different urban infrastructures also creates new cybersecurity risks (Elmaghraby & Losavio, 2014). Meanwhile, cities are increasingly being equipped with more sensors and data-driven processes. The challenge before us is therefore to find out how digital technologies and so-called 'big data' may be used for tackling urban problems while simultaneously mitigating issues related to a data-driven approach.

In reaction to criticisms on the smart city, both policymakers and scholars have recently directed their attention towards involving citizens in data-driven practices (Cardullo & Kitchin, 2017; Hemment & Townsend, 2013; Hollands, 2015). Next to municipalities, businesses and knowledge centers, urban governance would also need to include civil society, thereby giving local communities influence on what direction the smart city vision takes in practice (Baccarne, Mechant & Schuurman, 2014). Nonetheless, it remains largely ambiguous how and in which role citizens could be involved to counterbalance issues as diverse as corporate power and privacy concerns. By examining how public interests may be safeguarded, it becomes possible to take a step beyond mere praise or critique about smart cities (Söderström et al., 2014). Such an approach avoids both the utopian and dystopian thinking that is usually associated with new technologies (Vanolo, 2016). Instead, it offers a more comprehensive overview on what ingredients make up a smart city – both sweet and sour.

The aim of this study is thus to gain a better understanding of how the smart city vision is being translated into data-driven practices to address urban problems, how its related issues come into play and how public interests might be safeguarded. This leads to the following research question: *How can public interests be safeguarded in relation to smart city's logics and issues that follow from specific data-driven practices?*

Smart city in socio-technical perspective

Unravelling an urban vision

One way of looking at the smart city is to consider it as a vision or plan for achieving particular urban futures (Hall, 2000). Digital technologies and big data are then viewed as means for tackling a current problematic situation and clearing the way for a future desired situation, whether this be a more prosperous, secure, healthy, sustainable, inclusive or overall more livable city. The smart city vision typically assumes a direct transformative effect of technology on the governance of urban problems (Thrift, 2014). Many publications about the smart city focus exclusively on its technical dimensions and the impact thereof on urban life (e.g. Hashem et al., 2016; Pan et al., 2013). This position can be labelled as technological determinism (Gil-Garcia, Vivanco & Luna-Reyes, 2014), meaning that a causal relationship is assumed between innovative technologies and social change. For example, researchers have argued that the availability of big data and advanced analytics enable municipalities to make more real-time interventions on precise geographical scales than they could before (Batty, 2013; Kitchin, 2014b). Failing to meet a desired situation with data-driven projects is sometimes also attributed directly to technology, such as when it is not resilient against cyberattacks (Elmaghraby & Losavio, 2014) or when it takes away from the informality and unpredictability of cities (Greenfield, 2013; Krivý, 2016).

On the other hand, some researchers approach the smart city vision as fundamentally constructed by social actors (Hollands, 2008; Townsend, 2014) – in particular by large IT companies such as IBM, Siemens and Cisco. Söderström et al. (2014) describe how the smart city vision is mainly used for stimulating high tech entrepreneurialism and thereby serves the interests of global capital. Digital technologies and big data then play a role subordinate to organizational and institutional factors such as the transition towards a knowledge economy that relies significantly on high tech industries for urban (re)development (Kitchin, 2014b). This position can be labelled as social determinism (Gil-Garcia, Vivanco & Luna-Reyes, 2014), meaning that technology only plays a role as mediating mechanism between social forces affecting social change. Similarly, Hollands (2008) suggests that "the dominance of the entrepreneurial version of smart cities does not of course preclude the existence of different smart urban forms or examples, or the future development of more progressive models" (p. 315). The recent focus on citizen involvement in data-driven practices may be considered a step in that direction (Cardullo & Kitchin, 2017). Social determinists emphasize that human actors like policymakers, vendors, computer scientists and citizens actively construct the smart city through decision-making, interpretation, negotiation and action.

Recently, scholars have argued for taking a more explicit socio-technical perspective to the study of smart cities (Meijer & Bolívar, 2016). The pursuit of reconciling technological and social determinism into a single framework is reflected by a rich and long-running literature, such as socio-technical systems theory (Emery & Trist, 1960; Davis, Challenger, Jayewardene & Clegg, 2014), actor-network theory (Latour, 1992), structurational model of technology (Orlikowski, 1992) and technology enactment framework (Fountain, 2001; Schellong, 2007). These theories have in common that they attribute more equal weight to technological and social forces instead of considering one or the other as more important. While the earliest versions focused on explaining the functioning of industrial work organizations (Davis et al., 2014), a socio-technical perspective could also be applied to the functioning of a (digital) technology-facilitated mode of urban governance (Meijer & Bolívar, 2016).

This study proposes a general socio-technical framework for explaining data-driven practices in smart cities (see Figure 1). The framework integrates some of the earlier socio-technical thinking into a single model. Central is the notion of enacted technology, which can be defined as the perceptions, designs, implementations and uses of technology in a particular setting (Fountain, 2001). In other words, enacted technology delineates the functioning of digital technologies and big data as they are incorporated into a city's mode of urban governance: its logics, issues and mitigation strategies. The concept is therefore different from what technology enactment framework describes as 'objective technology'; i.e. the characteristics of a certain technology before it is used or adapted (Schellong, 2007). For example, while similar data analysis techniques may be used for urban governance as for managing a business, the way in which these techniques are enacted could be worlds apart. This does not mean, however, that technology itself has no influence at all. According to Thrift (2014: p. 1263): "You don't have to be a technological determinist […] in order to be able to argue that cities are being changed by information technology. They have been and they are being". The duality of technology (Orlikowski, 1992) implies that enacted technologies are simultaneously:

1. Constructed by social actors in particular ways (e.g. designed, developed, appropriated and modified), often following the institutional properties that guide people's interaction with technology (e.g. socio-economic conditions, politics, legal contexts, design standards, norms and organizational arrangements);
2. A structural influence on social actors by facilitating some of their actions and constraining others, which may in turn reinforce or transform certain institutional properties (e.g. the distribution of wealth, roles of government in society, citizen-state relations).

Deciphering the associations between technology, social actors and institutional properties is a complex task. Moreover, these interrelationships play out in a specific spatio-temporal context of contemporary cities. Actor-network theory teaches us that an enacted technology can only be studied by tracking the assemblages of its human and non-human parts (Latour, 1992). This means that the data-driven practices put forward by the smart city vision consist of "many apparatuses and elements that are thoroughly entwined, and develop and mutate over time and space" (Kitchin, 2014a: p. 24). While each socio-technical assemblage is of course unique, it is expected that commonalities may be observed when examining how numerous data-driven practices become enacted. The next two paragraphs consider the technological and social side of smart cities in a bit more detail.

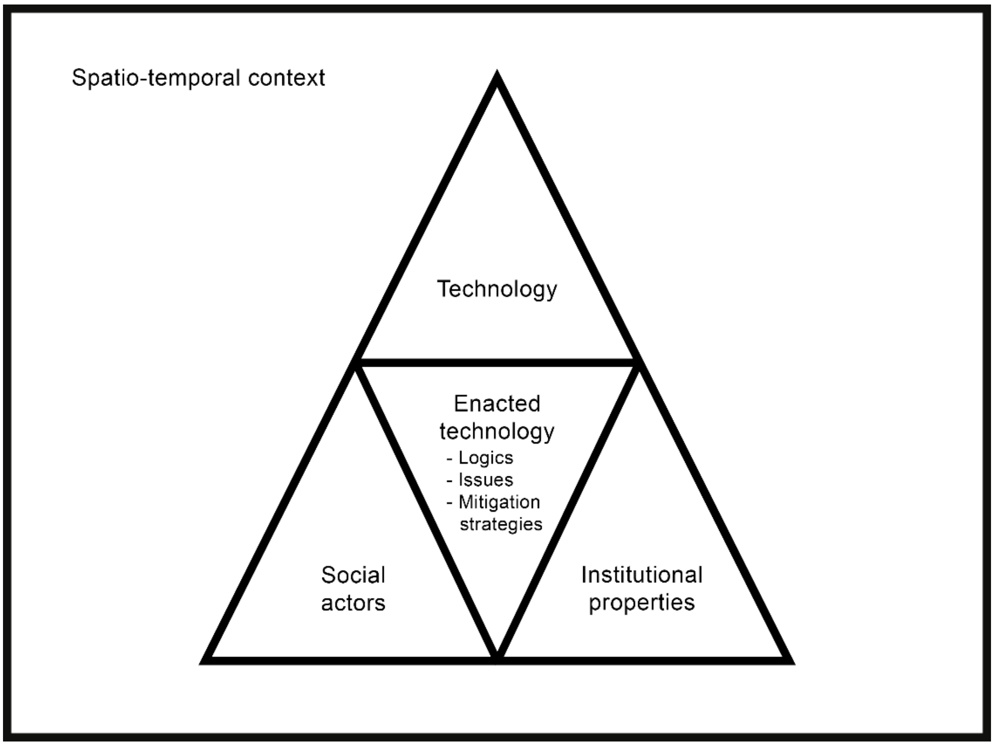

Figure 1. General socio-technical framework for explaining data-driven practices in smart cities.

Big data urbanism as the technical side of the equation

The emergence of a data deluge has been widely documented in the literature (Anderson, 2008; boyd & Crawford, 2012; Mayer-Schönberger & Cukier, 2013). In general, it is possible to distinguish three common sources of this development in contemporary cities. The first and also the most traditional are data from public organizations. Townsend (2014: p. 5) states that "each time human settlements have grown larger, advances in information technology have kept pace to manage their ever-expanding complexity". Most if not all administrative records of cities are nowadays digitalized, such as those of municipality officials, police officers, tax authorities and health care providers. A related development over the last two decades has been the provision of online information and services by e-government applications (Moon, 2002). The use of data for urban governance is thus not an entirely new phenomenon. Municipalities and public research institutes have long assembled data on the state of affairs in cities. For example, by means of census tracts and neighborhood surveys, but also through CCTV security cameras and traffic management systems (for an early example, see Honey, 1969). Still, not everything is the same. Evidence-based policy making used to refer to longer-term evaluation studies (Sanderson, 2002), but is increasingly associated with a more continuous form of data collection and linking of datasets (Kitchin, 2014a/b).

Second, a lot of data in contemporary cities originates from consumer society. Since the widespread adoption of the internet it is possible for individuals to exchange more forms of information than ever before through a single medium (Castells, 1996). Wireless connections, smartphones and social media have even made it possible to stay in touch with anyone, anywhere and at any time. The constant digital traces that individuals leave behind in this way are typically registered by large internet companies like Apple, Google and Facebook (Townsend, 2014). Many other businesses also take part in large-scale consumer data collection (Kitchin, 2014a/b), such as specialized data brokers, advertising industries, mobile network providers, GPS navigation manufacturers, public transportation companies, (online) stores, financial institutions and energy suppliers. Although the internet may seem similar to a public space, allowing individuals to move and express themselves online freely, much of its digital infrastructures are privately owned and serve some form of profit-making. The internet may thus better be compared to the public-private hybridity of modern shopping malls (Papacharissi, 2009). Most commercial services today require at least some form of user registration up front and also track user patterns, which can be anything from financial transactions to web activity and from electricity consumption to subway check-ins. Companies use these data for innovating their products, services and business models through business intelligence (BI) analytics (Ohata & Kumar, 2012).

An increasingly common third form of data in modern cities follows from the urban environment itself. Not only do more people have access to the internet, but in recent years also more and more things (Batty, 2013). Some authors even claim that in the near future more objects, like cars, fridges and street lighting, will become virtually connected than are personal devices (Atzori, Iera & Morabito, 2010). This development is typically described as the Internet of Things. Both public and private parties may equip objects in urban space with sensors to enable the monitoring of their operation and/or surroundings. Just a few examples of these digital senses are cameras, pressure detectors, microphones and air quality sensors. While specialized sensing equipment has been part of the urban landscape for quite some time, their unprecedented scale of deployment and connection to the internet currently entails the formation of a new digital skin for cities (Rabari & Storper, 2015).

Altogether, these three forms of digitalization imply an ever increasing volume, variety and velocity of urban data flows (Chen & Zhang, 2014). Big data are thus not only explained in terms of size (Batty, 2013), but also by reference to their diversity and their increasingly fast or even real-time nature (Kitchin, 2014b). Scholars describe the spatio-temporal omnipresence of ICT in everyday life with terms like ubiquitous computing, pervasive technology and 'everyware' (Dodge & Kitchin, 2007; Greenfield, 2006). However, the value of big data can solely be exploited by employing advanced data management and analysis techniques (Kitchin, 2014a). Hashem et al. (2016) show how information management becomes a challenging task in smart cities because of huge data storage demands, unevenly structured datasets that may need to be prepared and/or linked first, and processing systems which must be flexible enough for handling quick in- and outputs. Various analysis techniques are used for finding patterns and predictions in big data (Kitchin, 2014a). Some of these are relatively traditional, like statistical tests and simulations. Others are new, such as machine learning and artificial intelligence. The most advanced techniques enable computers to gather insight from data relatively independent from human operators and existing hypotheses (Townsend, 2014). Moreover, since urban data are typically associated with specific places, geographic information systems (GIS) could be applied as well in data-driven projects (Batty, 2013).

Ultimately, the assembly and analysis of big data yields frequent or even real-time feedback for the application of policy interventions (Goodspeed, 2015). These data-driven practices may be illustrated with a cybernetic loop (see Figure 2). Wiener (1948) defines cybernetics as the study or management of systems by using information retrieved from those systems themselves. An important assumption of the smart city vision seems that bounded rationality in human decision-making (Simon, 1997), such as by incomplete information or bias, could be overcome with the supposed measurability, objectivity and neutrality that big data urbanism provides (Kitchin, 2014b). The automatization that is inherent to data-driven practices makes of technology even more so a force on its own in socio-technical assemblages (Coletta & Kitchin, 2016; Thrift, 2014). In fact, some technological systems are now able to independently sense (e.g. real-time data from sensors or automatically scraped from the internet), think (e.g. machine learning and artificial intelligence) and act (e.g. actuators, drones and algorithmic decision-making). Important to emphasize is that, while described here in theory, the functioning of data-driven practices will depend on how technologies become enacted in a particular city.

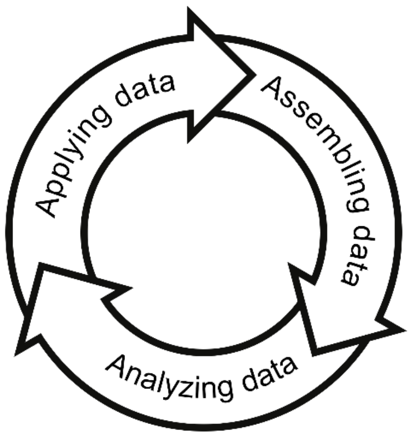

Figure 2. Triple A's of data-driven practices forming a cybernetic loop.

Smart citizens to stir up the mix?

Despite that residents are considered the main beneficiaries in the smart city vision, a frequently heard critique is that its implementation would follow a top-down approach without taking into account the perspective of citizens themselves (Cardullo & Kitchin, 2017; Hemment & Townsend, 2013; Hollands, 2015). First, perhaps the clearest illustration to this argument is the construction of smart cities from scratch in places where no existing population is living yet through public-private partnerships (Sennett, 2012; Shelton, Zook & Wiig, 2015). For example, India has plans for building a 100 smart cities across the country (Datta, 2015). These will all come fully equipped with cutting edge digital technology to address urban problems like pollution and traffic congestion. Treating new cities or newly built districts of existing cities as an empty canvass for technological masterpieces, however, denies the (future) local population a development path of their own imagining and risks a vendor lock-in (Vanolo, 2016). Sennett (2012) argues that smart cities from scratch will lack the informality and organically evolved character that make urban areas around the world such attractive and dynamic places to live for many people. Therefore, he prefers an experimental, coordinative and open approach to data-driven practices.

Second, the smart city vision on urban governance has been criticized for favoring corporate power over citizen power (Hollands, 2008; Söderström et al., 2014; Townsend, 2014). For example, Kitchin (2014b) notes how data-driven practices are promoted by large IT companies "who view city governance as a large, long-term potential market for their products" (p. 10). Digital technologies and big data applications would then be pushed from the supply side, instead of serving real demands of local communities and municipalities (Angelidou, 2015; Galdon-Clavell, 2013). Moreover, Hollands (2008) notes how data-driven practices tend to be utilized by municipalities for strengthening their position in inter-city competition over global capital and highly-educated professionals, thereby reinforcing urban inequalities. He argues that a progressive and inclusive smart city needs to start with actively involving its residents and address their unequal digital skillsets; i.e. new digital divides. According to Krivý (2016), Hollands does not specify though how people should be empowered and educated with regards to data-driven practices: when to embrace and when to resist them?

Third, the critical literature depicts urbanites as vulnerable to subjugation by data-driven practices (Galdon-Clavell, 2013; Krivý, 2016; Vanolo, 2016). Big data greatly expand the opportunities for monitoring characteristics, behavior, interactions and transactions of citizens. This has led some scholars to compare the smart city with a panopticon (Kitchin, 2014b; Klauser, Paasche & Söderström, 2014). The panopticon is a prison design by Jeremy Bentham in which an invisible guard can maintain order because prisoners feel constantly watched. Van Zoonen (2016) notes how personal data used for surveillance purposes may raise significant privacy concerns. On the other hand, she argues that impersonal data used for delivering services will be of a lesser or even no concern at all. While citizens become ever more transparent by means of big data about their lives, the processes of data assembly, analysis and application remain mostly invisible to them (Townsend, 2014). For an individual it is hard to figure out what exactly a data-driven project entails and if there would be any reason to worry about it. Lyon (2003) has warned for the categorization of people and places according to certain risk or worth profiles. He describes this process as 'social sorting'. Although some level of categorization is inherent to data-driven practices, the danger is that computer code may be used for separating the privileged from the marginalized (Graham, 2005). Even when no discrimination is intended, relatively autonomous techniques like machine learning and artificial intelligence could reproduce social inequalities that already exist in the datasets (Pasquale, 2015). Krivý (2016) argues that instead of just providing government officials with a new toolset for surveillance and discipline, digital technologies and big data increasingly exert an environmental-behavioral control over citizens. For instance, data analyses may drive (automatic) reconfigurations of the physical and virtual choice architecture to make undesired behavior impossible while providing nudges for desired behavior. To Morozov (2013) the fundamental question for every citizen must be which problems are so urgent that we are willing to give up part of our privacy and autonomy in return for a digital fix, and which problems are just inconveniences or require a non-technical solution.

In response to the controversies about top-down smart city implementation, policymakers and scholars have directed their attention towards involving citizens in data-driven practices (Hemment & Townsend, 2013; Hollands, 2015). Based on Arnstein's (1969) classic ladder of citizen participation, Cardullo & Kitchin (2017) distinguish four levels of so-called 'smart citizen participation' (see Table 1). The lowest level refers to a situation where residents are only passive subjects whose data is used for steering them in certain behavioral directions. Such non-participation may be framed politically as a form of paternalism. The next level approaches citizens as consumers who are able to choose particular data-driven services and turn down others, thereby following a market discourse. Tokenism allows urbanites to get informed and/or share their feedback on a data-driven project. They may assume a role as proposer of ideas, perhaps based on their participation in the project as tester, while in other cases they are only recipient of information. The highest level is referred to as citizen power and it describes the situation where residents take on an active role such as member or co-creator of data-driven projects. For example, they may be involved in producing measurements of problems in their own living environment. This relates closely to developments such as the quantified self movement and citizen science (Heyen, 2016). The difference between these two being that citizen science is typically set up by organizations while quantified self is initiated citizens themselves. Although co-creation might be a noble effort, Vanolo (2016) warns that not everyone has the same digital skillset to participate equally and that the responsibility for urban problems risks being shifted towards local communities.

Table 1. Smart citizen participation ladder (adapted from Cardullo & Kitchin, 2017: p. 6).

Participation level	Role of citizen	Type of involvement	Political discourse
Citizen power	Leader/member, decision-maker, co-creator	Vision, leadership, ownership, create, negotiate, produce	Citizenship, deliberative democracy, commons, co-creation
Tokenism	Proposer, tester, recipient	Suggest, feedback, informed	Civic engagement, participation
Consumerism	Consumer	Browse, choose, consume	Capitalism, market, neoliberalism
Non-participation	Data-point, patient, subject	Steered, nudged, controlled	Stewardship, technocracy, paternalism

Examining smart cities in the Netherlands

This study employed a qualitative research design to explore data-driven practices in the five largest Dutch municipalities: Amsterdam, Rotterdam, The Hague, Utrecht and Eindhoven. Four of these have a longstanding collaboration in the G4 platform with regards to innovative urban policies. Eindhoven was added because of its high tech economic profile and outspoken smart city approach. Whereas smart cities like New Songdo in South-Korea or Masdar in the United Arab Emirates are built from scratch (Sennett, 2012), the five Dutch cities have a relatively long history and take a more fragmented approach to integrating digital technologies into their mode of urban governance. Data-driven practices are thus organized as experimental pilots instead of major top-down projects. A focus on 'already existing smart cities' has been recommended by previous research (Shelton et al., 2015) since it enables the investigation of how the broad smart city vision becomes enacted into the socio-technical assemblages of specific places. One way to go about this would be to zoom in on a particular data-driven project and make a detailed case study of how each element – technology, social actors, institutional properties and spatio-temporal context – contributes to the enacted technology. Instead, the current study takes a comparative approach to examine commonalities in the socio-technical assemblages of numerous data-driven practices. This allows for making more general statements about the enacted technology in terms of logics, issues and mitigation strategies.

The analysis draws upon six semi-structured interviews with smart city professionals working in local government, and five with professionals working in civil society organizations. Each interview took on average one hour and was typically conducted in the workplace of participants. A topic list was used to query participants about their understanding of the smart city vision, specific data-driven projects, and strategies to deal with related issues. Consent for recording the interviews was requested beforehand and a certain level of anonymity was guaranteed by reporting only the names of municipalities and civil society organizations. After each interview a short journal was updated to keep track of any remarkable observations (e.g. participants' state of mind or the interview setting) and recordings were fully transcribed. Additionally, participant observation was applied during ten meetings about smart cities and closely related topics (e.g. one meeting by the G32, which is a collaborative platform for midsized cities in the Netherlands, and several meetings by knowledge centers and civil society organizations). Field notes made it possible to keep track of the content, audience and interactions at these attended meetings. Relevant policy documents of the five municipalities were collected such as council letters, strategic texts, implementation programs and progress reports. These documents proved useful in adjusting the topic list of each interview to the local setting. For example, participants could be asked about specific smart city approaches or data-driven projects mentioned in the policy documents. Finally, all interview transcripts and field notes were coded in the analysis procedure. This included making comparisons between the fragments about specific data-driven practices and between fragments of participants pronouncing particular perceptions or experiences about the smart city, thereby establishing some common themes. After an iterative process of coding, data collection and recoding, the final codes could be determined on which the reported findings are based.

Smart city professionals in local government were identified through policy documents, news articles, LinkedIn profiles and attended meetings. It turned out that relatively many civil servants are involved with the smart city vision in their work. Therefore, it was essential to select only those officials who have the best overview of data-driven practices in their respective municipality, maximizing the utility of information in the sample. Participants were typically project managers or strategic advisors whose function is tied to a municipality-wide smart city program, but sometimes also to a particular department (e.g. information management). In most cases it was possible to arrange a single interview with one or two relevant local government officials. However, in The Hague it was necessary to conduct at least two interviews since relevant information was more spread out over different programs and departments. A few municipality officials mentioned that receiving many interview invitations, both by researchers and journalists, made them somewhat hesitant to participate in the study at first. Nonetheless, without exception, participants showed great enthusiasm to discuss their understanding of the smart city vision and their experiences with data-driven practices. Participants especially appreciated the questions that were adjusted to their local setting. Building trust at the start of each interview, by making small talk and explaining the interview content and procedure, also contributed to the overall smooth process. One exception was that some participants showed reluctance to speak openly about issues in data-driven projects. Even though largely anonymous, they feared it could hurt the municipality's image. When necessary, this was resolved by allowing participants to discuss smart city's issues in terms of their broader experience instead of with examples from specific data-driven projects.

Smart city professionals in civil society organizations were largely sampled through snowballing techniques, referrals from municipality officials and attended meetings. These organizations were selected based on two criteria. First, they had to actively involve citizens with data-driven practices in their respective municipality. De Lange (2017) notes that it is relatively common for Dutch civil society organizations to fulfil such a position. Second, the organizations needed to proclaim a critical outlook on the smart city, thereby complementing information gained about smart city issues from municipality officials. In total, five interviews were conducted with smart city professionals in civil society organizations – one for each of the five municipalities. These organizations can best be described as working on the interface between culture, science and technology: Waag Society Amsterdam, Creating010 Rotterdam, ICX The Hague, SETUP Utrecht and DATAstudio Eindhoven.

Logics of data-driven practices

Even though data-driven projects were mainly implemented as small-scale pilots, a relatively large amount and variety of initiatives could be observed in the five municipalities. Overall, various forms of data assembly, analysis and application emerged. The most commonly used data were linked datasets of public organizations, which were often also made available as open data. These included sources from municipality departments, public research institutes such as Statistics Netherlands and executive professionals like the police or health care providers. Linking datasets sometimes required a cross-sectoral approach since the data needed for particular projects could not always be retrieved from a single policy domain. In fact, municipality officials related the technological focus on linked public datasets to wider institutional trends towards working in multidisciplinary teams on urban problems instead of taking a more hierarchical and sectoral approach. Such findings are consistent with earlier work on digital-era governance that stresses the reintegration of decoupled policy tasks, needs-based holism and digitalization of administrative processes (Dunleavy, Margetts, Bastow & Tinkler, 2006). Indeed, most research participants considered the smart city vision as a process of organizational change in which all social actors involved with urban governance learn about the value of big data. In light of the smart city vision, it seems that municipality officials are (re)discovering what extensive information is already available in the public domain and how this might be used in new ways through more advanced data analysis and application techniques: "*The assumption was, and that was mostly correct, that we have a lot of data – also as a municipality – which are underutilized. So far we retrieve insufficient value from that data. The possibilities reach far beyond what are we doing now. And not just our data, but also other people's data*" (Municipality of Utrecht).

Consumer data were less common in the observed data-driven projects because these often needed to be purchased or shared under complex public-private arrangements. On the other hand, automatic web scraping tools sometimes facilitated the direct extraction of big data from the internet without having to arrange access to underlying databases that are predominantly owned by private parties (Kitchin, 2014a). Technology then overrides institutional barriers. Social media data, for example, were utilized by municipalities to complement other sorts of data. However, in none of the observed projects was it the main form.

Internet of Things applications could be found in all of the five municipalities. Especially in those areas that were designated as so-called 'living labs'. These are physical places or areas where collaboration between municipalities, businesses, knowledge centers and end-users (e.g. citizens) is supposed to drive innovation that benefits all participating parties (Baccarne, Mechant & Schuurman, 2014). Research participants referred to living labs as places of experimentation and 'learning by doing'. Furthermore, the real-time nature of big data as described by Kitchin (2014b) was predominantly associated with practices around Internet of Things and less with the other types of data. Since these sensor data were still very much in an experimental phase, it is too early to speak of a fully fleshed-out digital skin for cities (Rabari & Storper, 2015).

In terms of data analysis and application, it became apparent that data-driven projects make relatively little use of the most automated techniques (e.g. machine learning and algorithmic decision-making). Social actors are in most cases still fulfilling an active role in the cybernetic loop or at least exercise some sort of supervision on it (Coletta & Kitchin, 2016; Goodspeed, 2015). Municipality officials preferred the use of (big) data for supporting everyday policy decisions and implementation: "*I think that steering is a wrong word. That is a vision on the data-driven approach that I do not support. I believe that information should support the implementation.. of how they clean the streets or how the police officer works, or the policymaker to make better decisions. […] I believe that information should never mean control, but always support. That is why we call our program data-innovation*" (Municipality of Amsterdam).

The practices of data assembly, analysis and application operated according to three different logics: entrepreneurialism, managerialism and communitarianism. These analytical categories function as ideal types in the Weberian sense because they convey the most important motivations given for developing a smart city. It should be emphasized that in reality data-driven projects were usually substantiated by more than one logic. Kitchin (2014b/2015) had already made some sort of distinction between data-driven entrepreneurialism and managerialism, referring to how the smart city vision conceives of digital technology as driving both economic growth and new forms of urban management. The addition of data-driven communitarianism, on the other hand, refers to the use of (big) data by local communities and civil society to address urban problems together.

Data-driven entrepreneurialism

The first logic to smart city development emerged from practices that aim to stimulate local economic development by means of technologically innovative projects. It thus relates closely to Harvey's (1989) classic work on entrepreneurialism in urban governance. However, instead of merely pointing out general inter-city competition processes, the comparison of numerous data-driven projects made it possible to respond to Krivý's (2016) wondering about "what makes then the smart city a specific form of entrepreneurial urban governance?" (p. 8).

Some central aspects of data-driven entrepreneurialism became clear from the 'NL Smart City Strategy' (Wamelink, 2017). This policy document is developed by the five largest municipalities and the G32, together with businesses and knowledge centers, to set out a shared agenda for developing smart cities. It mentioned how data-driven projects may be used 1) as a breeding ground for tech-startups, 2) as a strategy for attracting IT companies and skilled workers, 3) as a deregulated test yard for products that assemble, analyze or apply data, and 4) as an international export product for improving the competitive position and innovative image of Dutch cities.

At a meeting of the G32 about big data, the logic of data-driven entrepreneurialism was explained during a presentation by one of the present municipalities. The speaker noted that stimulating ICT-related economic growth and employment opportunities were explicit goals of their program. Bringing together tech-startups into a physical building would foster interaction with other businesses, researchers, students and governments. Program managers also actively approached companies to discuss how they might be able to participate in data-driven practices by developing new products, services and business models. Moreover, it was clarified how the program aims to attract computer science students to the city by offering them internships or PhD-positions at ongoing data-driven projects. The speaker expressed his hopes that students would afterwards stick around in the region and start businesses of their own, thereby referring explicitly to the idea of a knowledge economy (Kitchin, 2014b).

Indeed, the processes of data assembly, analysis and application sometimes functioned merely as a vessel for economic development: "*With innovative and energetic trajectories the idea itself is not always decisive, but the fact that there is energy, or that it is trendy, or that an interesting vendor is connected to it are already factors that influence the assessment of whether we want to proceed or not*" (Municipality of The Hague).

Data-driven projects were often linked to strengthening an economic profile or innovative image of cities, and thus fit well with city marketing initiatives. For example, the municipality of Rotterdam aimed to distinguish itself as a bicycle city. Related to this, they had equipped the traffic lights at a crossroads with sensors that can detect whether it rains, and when it does the cyclists may cross the street for a longer time than cars. While it is a relatively simple system, the processes of data assembly (sensors), analysis (no rain = 0; rain = 1) and application (timing of the traffic lights) are fully automated. A research participant of ICX The Hague explained how his city aims to distinguish itself as a tech-savvy 'Security Delta', which relates closely to the city's position as political and legal center of the Netherlands. Data-driven practices in the safety domain were therefore simultaneously connected to larger economic agendas of The Hague, such as attracting capital investments for cybersecurity companies. Whereas Rotterdam and The Hague connected some of their data-driven practices to a thematic profile, Eindhoven primarily used technology itself to foster an innovative image: "*Well, Eindhoven does have a tradition in this field. It is of course the city of Philips. It has a high-tech campus, it has a lot of Internet of Things related activity, among which are enabling technology companies that have their headquarters or research lab in Eindhoven on the high-tech campus. So they are very much into high-tech and also identify themselves with it. They see themselves as.. and find it important for the profile of Eindhoven*" (DATAstudio Eindhoven). An image as smart city ultimately served the economic interests of municipalities by attaining a higher ranking in city benchmarks, winning (inter)national prizes and being awarded prestigious European subsidies: "*We won the smart city lighthouse school.. 17 million euros of Horizon2020*" (Municipality of Rotterdam).

According to a research participant of DATAstudio Eindhoven, deregulation mainly occurred in living labs to facilitate quick breakthroughs in technology-based economic innovation. Open data programs of the five municipalities also aimed to foster an attractive business climate, in particular by opening up datasets of municipality departments and other public organizations. Open data portals would then facilitate companies to develop new products, services or even entirely new business models. However, several research participants noted how these open data are seriously underutilized. Instead, data-driven entrepreneurialism relied mostly upon new developments like the Internet of Things. One example is the living lab in Scheveningen, The Hague. In this project sensor equipment has been installed on lamp posts near the seashore, such as cameras that count pedestrian flows and sensors that measure air quality. The municipality aimed to make these lamp posts modular, so that new sensors and applications may be developed by businesses: "*What we are going to install is a smart infrastructure with poles.. […] that have USB-ports on the side and if you as a vendor or chain partner want to test a sensor or other kind of application, then it is possible over there. So we hope to find out whether there is any business model to this, whether there are related societal values.. and whether people are actually waiting for something like this*?" (Municipality of The Hague).

A relatively similar project with Internet of Things could be found in Eindhoven, called 'city beacons' (see Figure 3). Part of the city center has been equipped with pillars that feature multiple sensors (air quality, pedestrian flows, smartphone signals), an ad display on top (for commercial use and public notifications) and an interactive screen on the side (on which people may look up local events or navigate through the city for example). A research participant from the municipality of Eindhoven pointed out that this project was initiated by the company CityBeacon in cooperation with the city marketing organization Eindhoven365. Economic motivations, such as gaining ad revenue, have thus certainly played a significant role in the project. Moreover, CityBeacon and Eindhoven365 tried to claim the data that is being collected like this in public space as their property to make even more profit from measuring the city center in real-time.

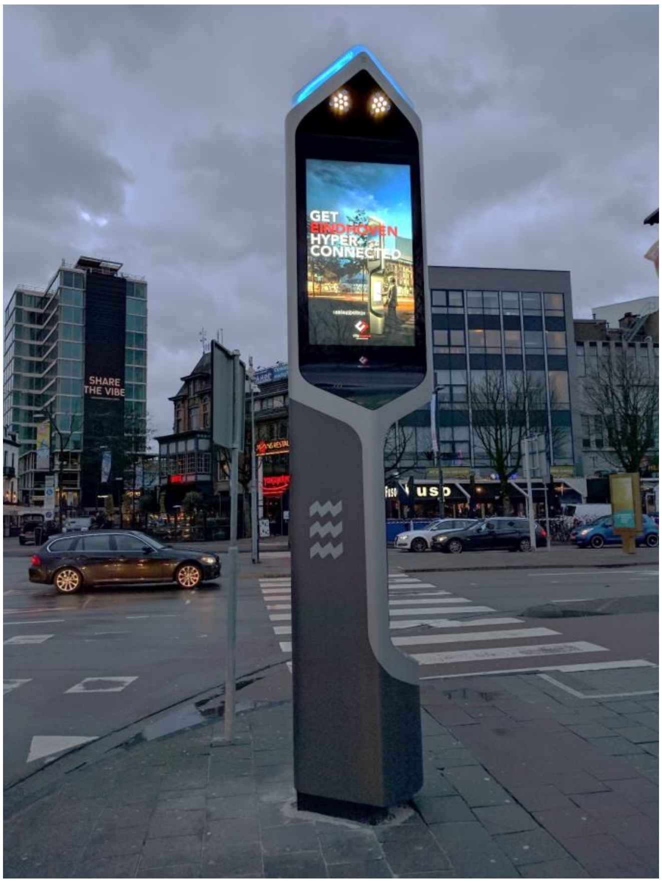

Figure 3. A city beacon on station square in Eindhoven (own photo material).

Data-driven managerialism

The second logic to smart city development followed from practices of monitoring, predicting and regulating urban problems by means of big data to facilitate urban management processes. It thus resembles earlier managerial modes of urban governance that focus on the role of local government in providing services for collective needs (Harvey, 1989). Clear associations were found with a commitment of municipalities to find better evidence for their policies, optimize management processes and ensure both discipline and control.

Data-driven managerialism showed considerable similarities to the concept of evidence-based policy (Sanderson, 2002), such as an aspiration for measurability, objectivity and neutrality in assessing urban problems. Research participants noted how data about the prevalence of neighborhood problems did in fact depoliticize some citizen complaints and decisions over where to deploy flexible teams of executive professionals. Still, a few important technological differences could be observed between the older data-informed managerialism and its more recent data-driven form: 1) increasingly real-time monitoring that enables intervention on precise spatio-temporal scale, 2) linked datasets that facilitate a cross-sectoral approach, 3) analysis techniques for deriving patterns and categories from big data more inductively, 4) new prediction and simulation methods for optimizing urban management, and 5) remote and/or automatic regulatory mechanisms. These characteristics relate closely to some of the previous literature on big data urbanism and cybernetic loops (Coletta & Kitchin, 2016; Goodspeed, 2015; Kitchin, 2014a/b). Moreover, several municipalities expected their role in the future to become less focused on the practical implementation of policy and more on the support of chain partners and executive professionals by means of data infrastructures and analyses. Municipality departments of Research and Statistics (R&S) would then develop into data expertise centers and gain a more prominent position in urban governance.

Research participants of the municipality of The Hague described how finding evidence for the development of new policy is an important aspect of their data-driven practices. Both the inductive approach to data analysis and the linking of datasets to facilitate more cross-sectoral insights were illustrated by one of their examples: "*There is no correlation between truancy and the weather. Even though we did expect so. I mean, you would not want to go walk outside when it is 5 degrees below Celsius, then you could just as well go to school. [...] Therefore, you must also examine more special relationships. [...] What if I look for patterns here, or if I add these data or this variable?*" (Municipality of The Hague). Instead of testing hypotheses, 'data-driven' often meant that datasets are inductively explored for any significant patterns and categories. This is why big data have also been described as 'the end of theory' (Anderson, 2008) or as a fourth scientific paradigm (Kitchin, 2014a). By exploring linked datasets of the built environment and the social domain, for example, it is expected that new insights for policy could be found. Another project in which finding evidence for policy stood central was the 3D-modelling of the built environment in Rotterdam. Referring to the upcoming Environment and Planning Act on a national level, the municipality aimed to employ simulations to test the effects of particular building measures and whether they fit with their existing zoning plans: "*So if you visualize it you can see oh no that is not something we want, that is too massive to build here. So you can interactively.. a proposal is made of what it will look like, what the shadow effects will be, what the noise disturbance might be if you build it*" (Municipality of Rotterdam).

Other data-driven practices aimed to optimize the management of flows and urban space, schedules, and the deployment of limited staff and budget. The most typical example of optimization was the use of so-called filling degree sensors in waste containers to schedule them for emptying more efficiently, thereby saving fuel, time and money for the municipal waste services. Both Amsterdam and Rotterdam had projects with these real-time sensors. Another project of managing flows and urban space was the bicycle parking system of Utrecht. By means of smart cameras in the bicycle storages an algorithm counts how many places are still free. Next, this information is displayed automatically through remote regulatory mechanisms such as a smartphone application and digital signposts in the city center so that cyclists will find a free spot more easily and not leave their bicycle just anywhere. A project for making schedules more efficient was observed in Utrecht and The Hague, where pediatricians time for each patient is predicted based on administrative data and their background characteristics. Moreover, the scheduling of public swimming pool maintenance in The Hague was based on smart sensors connected to the internet. Examples of optimizing staff and budget deployment could be found in Utrecht, where predictions on crime data helped to deploy their flexible enforcement teams (predictive policing), and in Eindhoven: "*Welfare organizations like Lumens offer a package of how they will provide services for a neighborhood that year. But we want a more customized approach. We want that they know that in this neighborhood there are more problems with youth and there with elderly, so that they can focus their efforts on that*" (Municipality of Eindhoven).

Data-driven managerialism was also associated with new forms of ensuring discipline and control by using digital technologies and big data to detect, categorize and adjust suboptimal behavior of citizens. In line with Lyon's (2003) work on social sorting, it was observed how some of the projects created data profiles to distinguish between (the probability of) problematic and non-problematic behavior. The difference between discipline and control was clearly explained by one of the research participants: "*You know, you have the old system and that is: you commit a crime, the police arrests you and the judge sends you to jail. And that is a sort of punishment, we all know that. […] But there is a new system emerging on top of this, which means that: you show suboptimal behavior, we modify that behavior by subtly steering you and then you will be an optimal citizen again*" (SETUP Utrecht). In other words, discipline is mostly about traditional regulation and enforcement. Control, on the other hand, relates to modifications in behavior through subtle nudges and changes in the virtual and physical choice architecture (Krivý, 2016). A research participant of Creating010 Rotterdam argued that some technologies might inherently tend towards discipline and control: "*Such technologies are often developed in the military industry. […] The satellite and the GPS, for example, were developed and funded by the military industry. Now these technologies have ended up in civilian life and that is mostly a good thing, but you still see that many technologies carry a sort of footprint or DNA for monitoring, surveillance and collecting data for a controller*" (Creating 010 Rotterdam). One project that aimed to discipline behavior originates from Amsterdam. Here, (big) data was used to prevent school dropout by monitoring absentees and giving school attendance officers an early warning when analyses showed increased risk. Another example of discipline through big data was found in Rotterdam to predict engagement in fraud: "*So all people with an unemployment benefit get a risk profile. […] And we are now testing this in real-life, so what is it going to yield? Yes, when it becomes obvious that this method leads to more hits, that you pick out more people who are engaged in fraud, then I have a good feeling this project will scale up*" (Municipality of Rotterdam). Perhaps the most advanced project that focused on control could be observed in Eindhoven. In Stratumseind, which is a nightlife area of the city and also functions as living lab, the municipality and its partners aimed to test the effects of certain color intensities of lighting on the behavior of people: "*If you are going to predict behavior on Stratumseind, so if the wind blows and the temperature is that high and there are so many people, then there is a higher chance on fights. But what if you also know how to dim or otherwise use lighting to calm people down?*" (Municipality of Eindhoven). Next to Internet of Things applications to measure the weather, noises and visitors counts in the area, social media data were employed in the project to take into account messages about Stratumseind that signify positive or negative emotions. Another project that featured control on behavior was an automated checkbook by the municipality of Utrecht to assist people with debts to get a better grip on their budget each month. The checkbook functioned as a form of algorithmic guardianship by automatically reserving or even transferring some money from the users bank account to creditors like the housing corporation or energy company for example. Whereas the project of Eindhoven uses a nudging mechanism to exert control, this project in Utrecht changes the virtual choice architecture to make excessive spending impossible.

Data-driven communitarianism

A third logic to smart city development appeared from practices of empowering local communities and civil society with (big) data so that they might actively help to address urban problems together. This relates closely to (neo)communitarian modes of urban governance that stress the importance of a third sector between state and market, grassroots mobilization, social capital and local networks (Gerometta, Haussermann & Longo, 2005). While previous research already noticed the increasing focus on active citizen power in the smart city vision as a mitigation strategy for some of its issues (Cardullo and Kitchin, 2017; Hollands, 2015), data-driven practices in the five Dutch cities point out that there may also be a communitarian logic to the development of smart cities.

Two main forms of data-driven communitarianism could be distinguished, namely bottom-up projects in which residents assemble their own data and initiatives that are based on open data. Both focus primarily on problems in the direct living environment of urbanites such as noise pollution and loneliness among elderly people. The NL Smart City Strategy, for example, noted how "assertive and well informed residents can contribute to solutions themselves by starting neighborhood initiatives and having access to relevant data" (Wamelink, 2017: p. 22). Overall, data-driven communitarianism was especially propagated by civil society organizations and open data divisions of municipalities: "*Partly it means that the data we have as municipality, who is where at what moment, could be made openly accessible so that others might produce clever solutions. For who says that I have the best solution with my ideas about how a city cleaner should work?*" (Municipality of Amsterdam).

Bottom-up projects in which residents assemble their own data were explained during a 'smart citizen talks' meeting at Pakhuis de Zwijger as (sensor) measurement initiatives by which residents can demonstrate the urgency of particular urban problems in order to gain political influence. In some cases these initiatives were started by residents themselves and in other cases they were started by organizations like the Netherlands National Institute for Public Health and the Environment (RIVM). This relates closely to earlier studies on respectively the quantified self movement and citizen science (Heyen, 2016). Research participants from civil society organizations stressed the importance of a sense of ownership among residents, since otherwise residents would quit rapidly when they perceive it as irrelevant and/or unpaid work. A research participant of Waag Society Amsterdam mentioned their project with 'smart citizen kits' in which open source sensor equipment was handed out to interested residents to experiment with measuring air quality in their neighborhood. Previous research discussed how this kit was developed and first used by Fab Lab Barcelona (Capdevila & Zarlenga, 2015) and another study showed how the sensor equipment was enacted in Amsterdam by residents who took on a variety of roles (Nijman, 2014), ranging from data producer to even guiding the process and thereby actively taking ownership. Nonetheless, technical difficulties and a legal context that determines what may be considered as valid and reliable measurement typically prevented these sorts of projects from actually achieving political power. An exception was a project by a local community in `s-Gravendijkwal, Rotterdam. The residents of this area experienced severe air pollution problems because of an adjacent road with heavy traffic, but according to estimated models by the municipality this problem should not exist. A community group then made their own sensor measurements and were eventually able to gain effective political power without taking legal steps: "*The municipality could no longer ignore it, so they had no other option than to respond to the factual information put forward by those residents. Meanwhile, I know for a fact that there are no longer any freight traffic allowed on the 's-Gravendijkwal*" (Creating010 Rotterdam).

Citizen initiatives that are based on open data aimed for increasing the self-organizing capabilities of residents by providing them with some sort of digital toolset: "*If you ask citizens to do something, then they also need to know what information is available and where to find it. They need to be able to base their actions on something*" (Creating010 Rotterdam). The municipality of Eindhoven aspires to become a 'smart society' by explicitly linking their open data program to wider institutional transitions towards a participatory society. For example, they had a pilot project in the living lab of Strijp-S where neighborhood watch groups are supported by a smartphone application that uses Internet of Things data to give real-time notifications when aggressive behavior is observed somewhere nearby (Sorama, 2016). These notifications are based on advanced microphones that are attached to some lamp posts in the district and can automatically distinguish ordinary noises (cars, people talking) from suspicious noise (screaming), which is a form of analytical categorization. Another project in Eindhoven, called WoonConnect, allowed residents of the neighborhood Eckart Vaartbroek to simulate the effects of particular renovation and energy saving scenarios on their house through 3D-modelling. Based on linked datasets about the built environment this project aims to facilitate citizens in saving costs, more easily apply for building permits and contribute to environmental sustainability. It is also related to the upcoming Environment and Planning Act.

Beyond just concerns about corporate power and privacy

In line with smart city critiques in the literature (Hollands, 2008; Krivý, 2016), research participants brought up issues of dominant corporate power and risks of subjugating residents to mass surveillance and control. Civil society organizations were especially critical about the lack of attention for smart city issues that they perceived: "*Nobody wants to disturb the party*" (SETUP Utrecht). According to them, there is little actual debate between proponents and critics as these mainly stay in their own camps where everyone agrees: "*There is going to be a smart city conference here soon. But all speakers had to pay, so everything you will get to hear there has a commercial value. I can already give away that there will be no sharp debate over de pros and cons of certain services and solutions that are presented there*" (ICX The Hague). Nonetheless, the issues of corporate power and privacy appeared not enough to capture all downsides of the observed data-driven projects. For instance, these concepts may be useful in formulating a critique on data-driven entrepreneurialism and managerialism, but they do not address the possible downsides of data-driven communitarianism. Moreover, using the frame of corporate power and privacy as central issues risks simplifying the debate that is needed about smart cities. A different distinction is thus proposed between technical-methodological issues and ethical-societal issues, which matches well with the findings of this study (see Table 2).

Table 2. Smart city issues

Label	Short description
Technical-methodological	
Availability and access to data	The functioning of data-driven practices often depends on what digital technologies and data are available/accessible
Quality of data	Limitations in data validity, reliability and representativeness remain important since error could lead to false positives or false negatives
Security of data infrastructures	Cyberattacks, system crashes and data leaks may threaten the functioning of data-driven practices
Social construction of data	Data-driven practices are not neutral, but are formed by choices and limitations in a specific social context
Limitations of datafication	Not all urban problems are equally knowable and solvable by means of data-driven practices
Ethical-societal	
Privacy	The private sphere of citizens may be threatened by data-driven practices through revealing their identity or sensitive information about them
Autonomy	Behavior of citizens can be steered by means of digital control mechanisms without their approval or knowing
Fairness	Data-driven practices can lead to unequal treatment by categorizing people, are not always proportional and risk that smart citizens become either a select group of people or are shifted all kinds of responsibilities
Transparency	Data-driven practices are typically invisible to citizens and increasingly harder to check up on
Corporate power	Commodification of data-driven practices often lacks connection to urban problems and makes urban governance dependent on IT companies

Technical-methodological issues

The functioning of urban governance increasingly depends on what data are available and who has access to them. This may create new inequalities between municipalities, businesses and local communities. While each municipality had an open data portal, research participants noted that these were heavily underutilized. Civil society organizations, on the other hand, noted that the data citizens are interested in are currently not available or accessible to them: "*The data you need for those type of questions [from citizens] is often very different than A- policy-focused survey data, and B- big data that is eventually aimed at predicting behavior or individual preferences*" (DATAstudio Eindhoven). Some complicating factors in making data openly accessible to as many social actors as possible were the costs of keeping such data up-to-date, fully standardized and interoperable, while simultaneously taking into account that some data are privacy sensitive. Overall, companies had more access to data from public organizations than the other way around. In the city beacon project of Eindhoven, for example, there was significant debate over keeping the Internet of Things data publicly available. While this was eventually achieved, a research participant of DATAstudio Eindhoven argued that still mostly just IT companies have the knowledge, skills and resources to truly access these data in practice and use them for analysis and application.

While it is sometimes argued in the literature that quality is less of an issue with big data because its size would correct for any impurities (Kitchin, 2014a), research participants actually did think of it as an issue. First and foremost because most data-driven projects used data that are not as exhaustive in volume as big data supposedly needs to be. Inconsistent data registration was perceived as an issue for all kinds of data. Projects in which residents assembled their own data, such as the air quality measurements with smart citizen kits of Waag Society Amsterdam, were often not considered reliable measurements according to standards fixed by law.

In line with previous research (Elmaghraby & Losavio, 2014), research participants perceived the security of data infrastructures (e.g. storage, computers, networks, data applications) as a major issue for smart cities. Recently, for example, the port of Rotterdam came to a standstill because of a worldwide cyberattack (Verschuren, 2017). Indeed, the municipality commented: "*How resilient are you really when all systems crash? Then you are not just talking about privacy anymore*" (Municipality of Rotterdam). According to a research participant from the municipality of Amsterdam, cities are just starting to grasp what dangers are actually out there: "*The risk that your data.. because they are not in an encrypted database with insurers, banks, but especially with governments, that those data are sold on the TOR-network, that is a much larger issue with impact on your life, and also cybersecurity and hackers and so on, than if I would lose my laptop or a USB-drive*" (Municipality of Amsterdam).

While data-driven practices typically treated (big) data as a more neutral and objective way of assessing urban problems than what the municipality of Utrecht described as 'gut-feeling', research participants also nuanced this by arguing that data are never truly neutral: "*Everyone who has a little understanding of data has very little confidence in statistics […] Because everyone knows that these numbers can be anything. Just like an audit, those numbers are relatively manipulable. […] And that is not very good for careful decision-making, because bias may create a too simple picture and lead to policies that do not match with the real world*" (Municipality of The Hague). The fact that choices and limitations in a specific social setting actively construct data was not only recognized in the literature (Kitchin, 2014a/b), but also in practice: "*So you could say that an algorithm is a magic box that produces a certain outcome, and thank you. But that is of course never a neutral process. Such an algorithm is made by people and those people make choices*" (Municipality of Utrecht).

A dogmatic belief in that datafication makes urban problems more knowable and solvable was criticized by research participants. Especially urban dashboards that bring together all kinds of (real-time) data about the city would reduce complex phenomena to a few numbers without any necessary interpretation: "*There is also an aspect of quantification to it that always makes me somewhat hesitant. Because you are then trying to catch a complex reality in models and you go measure it. But what comes out of these measurements is not necessarily a good reflection of what is happening in real life*" (Creating010 Rotterdam). Especially infrequent problems would be harder to detect with data-driven practices: "*There is a city where the suicide rate amongst women is much higher than in other cities. […] So that is a problem that would not exist in the standard data-driven methodologies.. because it is no big data. That leads to disastrous decision-making and is disastrous way of looking at society*" (Municipality of The Hague). Moreover, data-driven practices were criticized for mainly addressing symptoms of problems, but not their causes. For example, a research participant of Creating010 Rotterdam argued that the sensor project with traffic lights might benefit cyclists but exclude the policy alternative of a car-free city center.

Ethical-societal issues

Privacy concerns were mentioned by all research participants, but not as the most important issue since data-driven projects rarely use personal data. Still, the municipality of Amsterdam noted that retrieving data from open text fields in forms led to some challenges. Because the content of these text fields is free to fill in by citizens, it is hard to determine if there could be any privacy sensitive data involved. Instead of focusing on individual-level privacy, a research participant of DATAstudio Eindhoven argued that big data make individuals transparent as members of groups, thereby still revealing multiple aspects about a person's identity. In line with previous literature (Van Zoonen, 2016), privacy concerns were more apparent with some data-driven projects (e.g. surveillance on fraud) than with others (e.g. managing bicycle flows through the city). Moreover, the concept of privacy was often reframed or used as a starting point for discussing all kinds of ethical-societal issues: "*To me, the smart city is a kind of puzzle piece, a blind spot in seeing what privacy is truly about: the right to be imperfect*" (SETUP Utrecht).

While relatively few data-driven projects made use of the most automated techniques, especially civil society organizations outlined a dystopian future scenario in which invisible algorithms take away our autonomy: "*Let's start with the feared scenario. That is the scenario in which I do not understand anymore how I am being steered. […] When data-driven practices become such real-time and intelligent that there is no longer a level-plain field between myself and the controller that aims to steer me through big data, then you get a situation where I no longer understand why I do things*" (ICX The Hague). One example in which this might already be the case was the project at Stratumseind in Eindhoven. Since control is exerted through subtle nudges with lighting, visitors of the area might be steered in their behavior without their knowing and approval. On the other hand, a control project like the automated checkbook in Utrecht typically requires some form of user consent up front.

The fairness of some data-driven practices was questioned as well. In line with previous literature (Graham, 2005; Lyon, 2003) research participants perceived the use of risk profiles, such as those employed in the fraud detection project of Rotterdam, as potentially discriminating against marginalized groups: "*That is an example of how it can go wrong. In the United States the courts made use of an algorithm that predicts the likelihood of recidivism. And after some time it became apparent that this system had a bias against black people. So yes, if you use it then you confirm the bias that was already built into the algorithm and dataset. So they stopped using it. But that is not an issue you can address with privacy, but it is something completely different*" (Municipality of Utrecht). The proportionality of data-driven projects was sometimes also criticized when a lot of effort had been invested in data assembly, analysis and application, but the results in terms of policy goals were only minimal. For example, it may be questioned whether the data-driven bicycle parking system in Utrecht really contributes to less nuisance of stray bicycles or if it is just a gimmick. Bottom-up projects in which citizens assembled their own data, like the one with air pollution in Rotterdam, were criticized for creating a select group of smart citizens that is highly educated and has a strong technical skillset: "*Yes, that is also a thing, it is actually a pretty well off neighborhood from Rotterdam-West where mostly higher educated people live. There are some higher educated residents who have developed this idea for themselves and know how to implement it. That would be quite a different story in Rotterdam-South where many lower educated residents live and who have little grip on what is happening out there*" (Creating010 Rotterdam). On the other hand, a research participant from the municipality of The Hague argued that citizen science like projects and initiatives where citizens apply open data risk the shifting of responsibilities for urban problems towards local communities. These findings relate closely to arguments made by Vanolo (2016) and show that data-driven communitarianism might eventually benefit only advantaged groups, while putting an extra burden on disadvantaged groups.

Civil society organizations heavily criticized data-driven projects for their lack of transparency. This makes it nearly impossible for individuals who are not directly involved with the project to find out what data are actually assembled, how they are analyzed and what which applicable purpose. For example, the project at Stratumseind in Eindhoven was mostly invisible on the street: "*At the beginning of the area where you are monitored, there is a sign with a camera on it. But no words, only a symbol of a camera. Supposedly you are all informed then.*." (DATAstudio Eindhoven). Even the wording that is used to describe data-driven projects may reveal their operating, such as in the bicycle parking system in Utrecht: "*But they don't call them cameras, they call them bicycle parking sensors or something like that*" (SETUP Utrecht). Interestingly, the municipality of The Hague explained their lack of transparency by pointing out that they first want to figure out internally how to deal with all kinds of issues mentioned in this paragraph. They feared that making their pilot projects more public could lead to media outrage over (racial) profiling since they do not yet have the answers to all questions raised here.

Finally, corporate power was brought up as an important issue for smart cities that in some ways contradicts the entrepreneurial logic. Each municipality stressed that data-driven practices need to connect to actual urban problems, instead of merely arise from the supply-side of IT companies. This is in line with previous literature (Hollands, 2008; Söderström et al., 2014). Nonetheless, research participants also mentioned that since the tools and services for data assembly, analysis and application are produced by all kinds of IT-related companies, there is also a tendency towards the commodification of urban governance: "*We are not yet fully equipped. For example, we are now working on a tender for a new analytics platform. So we do not have all the right tooling for storing and analyzing data. That makes you quite dependent on companies like TNO*" (Municipality of Rotterdam).

A wide range of mitigation strategies

While the focus of the interviews was first primarily on citizen involvement, research participants noted that many more ways of safeguarding public interests were relevant to their experience of data-driven practices. These could eventually be grouped under six strategies (see Table 3). However, it should be emphasized that neither these six strategies or the examples used to illustrate them are by any means exhaustive. Overall, it became clear that mitigation strategies operated as reconfigurations in the specific technologies applied, social actors involved and institutional properties at hand. In other words, by changing the socio-technical assemblages of data-driven practices (Kitchin, 2014a).

Table 3. Mitigation strategies for safeguarding public interests

Type of strategy	Social actors involved	Examples
Technological	- IT producing companies - Technical engineers and designers - Data- and computer scientists, statisticians - Information management	- Privacy by design - Anonymization of data - Workflow management systems
Legal	- Government and politicians - Lawyers and legal advisers - Regulatory agencies	- Laws and regulation - Oversight and supervision
Political	- Government and politicians	- Democratic accountability and control
Organizational	- Project team - Data protection officer - Policymakers - Executive professionals	- Carwash method - Privacy impact assessment, societal cost-benefit analysis, ethics toolkit - Using complementary qualitative data - Learning about issues from pilots - Data library
Participative	- Project team - Civil society organizations - Citizens	- Participative design - Tinkering with digital technology and data
Informative	- Project team - Civil society organizations - Media, artists and designers - Citizens	- Information material in clear language - Books, documentaries and other media - Playful actions

Technological

Having a separate data-department or at least specialized staff, such as computer scientists and information managers, appeared essential for municipalities to implement technological mitigation strategies. For example, they were of major importance in addressing issues like data accessibility, quality and security by providing standardized data registration, preparing datasets to make them openly accessible, checking data for quality and error margins, and securing data storage. Specialized staff made municipalities in general less dependent on IT companies for setting up data-driven projects. Next, research participants mentioned some very specific technological strategies for addressing smart city issues. One of these was privacy by design, which means that during the development of a technology and its appropriation in a specific project it is ensured that no personal data can be collected. The underlying principle is data minimalization, so that only those data are collected which are absolutely necessary for the purpose of a particular project. For example, the project of data-driven bicycle storage in Utrecht only counted empty spots by means of Internet of Things enabled cameras without storing the video footage: "Then *I mailed these companies in Utrecht, like how does this work? And they told me they have cameras that work with algorithms to count empty spots. So I asked how does that work in practice then? Does it go to the cloud? No it does not go to the cloud, it is locally calculated on a Raspberry Pi or some similar system. So they did put some thought into it*" (SETUP Utrecht). Building on the notion of privacy by design, research participants mentioned value sensitive design as an approach that also takes issues like autonomy into account from the start of a new technology. When personal data was collected, municipalities typically anonymized the dataset by decoupling personal data from other types of data or by aggregating the dataset to a higher level (e.g. group or neighborhood). A research participant of the municipality of The Hague emphasized that it is very important to document all choices and limitations during processes of data assembly, analysis and application, thereby making the social construction of data more transparent. To achieve this aim, technical staff could make use of workflow management software (Scheider, Ostermann & Adams, 2017).

Legal

Recent changes in the legal context were perceived as important new safeguards for public interests. The most commonly named example of this is the European General Data Protection Regulation (GDPR). While a comprehensive reflection on this law is beyond the scope of this study, it should be emphasized that the GDPR obligates multiple other mitigation strategies such as privacy by design and the documentation of choices and limitations during the social construction of data-driven projects. In this way, the GDPR might be considered a safeguard for the implementation of many other safeguards: "*The GDPR and the European guidelines are upcoming of course. They also play a role in the projects that I am involved with. […] At a higher level, there is now a manager who is going to examine.. by taking into account the European guidelines, or law.. what we must do in addition to what we are doing already to make sure that everything is properly safeguarded?*" (Municipality of Rotterdam). Civil society organizations were also mostly pleased with the new European regulations: "*It is a compromise, but there is literally a sentence […] about that people cannot be categorized by automatic scoring systems alone […] They have also arranged that from 25 May 2018 onwards every service and product needs to be able to account for how they have thought about privacy at the start. I am not sure which form it will take, but the fact that I can go write an angry letter and refer to this law is amazing!*" (SETUP Utrecht). An example of legal safeguards on a local level could be found in relation to Eindhoven's city beacon project. The producer of this Internet of Things application and the city's marketing agency wanted to claim all collected data. However, the municipality developed open data principles and turned these into local regulation to make sure that all data that is collected in public space would stay public property. Issues of accessibility, transparency and corporate power could therefore be addressed to some extent: "*So for instance we say that data collected in public space are public property […] The open data principles are actually rules for how we want to do things here in Eindhoven. […] And Amsterdam joined as well. […] Antwerpen joined too. So that is something we do in teams with lawyers and other people that know how to arrange these rules. […] So that is a role we want to take. You must protect your residents with these big developments*" (Municipality of Eindhoven).

Political

The political arena is perhaps the most logical place for safeguarding public interests, since governments are accountable for their practices and representatives exercise control on this. Colleges of mayor and aldermen (B&W) were indeed often named by municipality officials as leading the direction a smart city vision takes in practice. For example, the open data principles in Eindhoven and later in Amsterdam mentioned above were the initiative of two aldermen. City councils also fulfilled their role, for example by asking critical questions when necessary: "*Privacy is very hot. Really hot. So when there is only the slightest suggestion that something is not well with privacy, then the city council is on top of it*" (Municipality of The Hague). A specific example of political strategies in The Hague was found in relation to the SmartBox project, which is very similar to the fraud prediction project of Rotterdam described earlier. Councilwoman Fatima Faïd of The Hague City Party asked some critical questions about the project (Bertram & Van Aartsen, 2014). For example, she queried which variables are exactly used in the system and who decides about this; i.e. the social construction of data. Moreover, she criticized the fairness of using a variable for visiting the same holiday country as a risk factor in data analysis. According to her, this could lead to more false positives in predicting a risk on fraud for residents with an immigrant background, since these regularly visit family in their country of origin. Moreover, Faïd questioned the proportionality of using data-driven practices in this way. As a defense, the college of B&W argued that variables are selected by municipality officials based on earlier success in detecting fraud, that visiting the same country is just one variable that contributes to a combination of risk factors, and that current resources for detecting fraud are inadequate.

Organizational

An important task for project teams was to check with policymakers and executive professionals which data-driven practices are both feasible and contribute meaningfully to urban problems. This was described by a research participant of the municipality of The Hague as the 'carwash method'. Program managers took on a role as information broker between municipal departments to find out which data could contribute to addressing urban problems, thereby also facilitating the cross-sectoral approach mentioned earlier. Moreover, they slowed down or stopped projects that were initiated merely because of the trendiness of digital technologies and also refused to cooperate with companies that use data as their direct business model instead of providing a service or product.

A different organizational strategy was to hire specific staff, in particular data protection officers, to safeguard public interests. While having a data protection officer will become mandatory by European law in 2018, most municipalities already had at least one for safeguarding the security of data infrastructures and privacy protection. For example, by using privacy impact assessments (PIA) to examine possible issues with data-driven projects. While most focus is placed on safeguarding privacy and data security, the municipality of Utrecht described a more comprehensive tool for assessing smart city issues: "*We have made a guide and poster with the university to show all kinds of decision-making processes. It is also about bias in datasets and privacy. But you could say that it starts with an exploration about ethics and if we are doing that, then privacy is only a sub-form and you have to take care of that too in the PIA. These ethics are really all about balancing between are we doing well, are we transparent enough, and if it goes wrong.. what do we do then?*" (Municipality of Utrecht).

Several municipalities aimed to tackle the limitations of datafication by taking into account other forms of knowledge, such as qualitative data and the interpretations of policymakers and executive professionals: "*There is also qualitative data, you have hard and soft data. […] That is why we hired a designer at the strategic sector. She retrieves soft data from the neighborhoods and we tie that to the hard data. […] She holds several sessions in these neighborhoods and talks to residents, thereby effectively mapping what is going on*" (Municipality of Eindhoven). The municipality of Utrecht organized regular 'knowledge circles' to discuss the functioning of data-driven projects with policymakers and executive professionals and so they could contribute their interpretations.

Research participants typically perceived the organizational form of pilot projects as an advantage for safeguarding public interests. This relates closely to Sennett's (2012) argument for an experimental, coordinative and open approach to data-driven practices. For instance, both municipality officials and civil society organizations described how an experimental and open approach allowed for 'learning by doing', including about the possible downsides of data-driven practices and how to deal with them: "*If you can have a kind of beta-lab, a place where you can semi.. safely experiment with technology, make quick progress and develop prototypes. Show what technology can and cannot do, before you start a lengthy tender.. so that you have a good idea of whether it will work well*" (Waag Society Amsterdam).

Instead of merely having an open data portal online, several municipalities aspired to develop a data library where supply and demand for data may be brought together. This would in turn increase the availability and access to data: "*In the roadmap next economy we proposed to identify a data-exchange. That is really nothing more than a kind of library where you can go to, and where someone helps you to find your data. And also take care of some funding when it concerns commercial data, or if it is open data you can just take it. […] There they can also determine how often data should be made up-to-date, so you can return that to the municipality or other parties*" (Municipality of Rotterdam).

Participative

One of the most mentioned participative strategies was what a research participant of Creating010 Rotterdam described as participative design. Project teams played an important role in this strategy by finding out the needs and concerns of residents about specific data-driven practices. An example was the Healthy Longer at Home project of the municipality of The Hague. In some senior housing all kinds of digital technologies were tested for their ability to assist the elderly in living independently for a longer time. Right from the start of this project a test panel of elderly was involved to regularly discuss their needs and concerns. Based on these discussions only those technologies were selected that are in line with what the elderly residents wanted. On the smart citizen participation ladder (Cardullo & Kitchin, 2017) the project could thus be described as a strong form of tokenism, having residents test and suggest about digital technologies. In negotiations between the elderly panel and the project team it was eventually decided that no data would be collected for now, thereby safeguarding privacy: "*The idea was first to make this project about data collection with sensors so that we could use it in dashboarding the city. I prevented that and said no, because we are dealing here with the most personal data there is*" (Municipality of The Hague). Since negotiation and co-creation was observed, the project also had characteristics of citizen power (Cardullo & Kitchin, 2017). Including elderly residents as participants was praised by civil society organization ICX The Hague because they are not the typical select group of smart citizens. A research participant of DATAstudio Eindhoven mentioned how their workshop with residents in the neighborhood Woensel-Noord also employed participative design. More specifically, it was discovered how contact frequency was an invalid measure for loneliness among elderly residents since it did not match their experience, which was about contact intensity.

Improving the accessibility of data-driven practices and counterbalancing corporate power were explicit goals of a second participative strategy, namely tinkering with digital technology. This featured activities like hackathons and data bootcamps were residents could try crafting something with open data or sensor equipment, usually guided by some technical specialists. Civil society organizations especially perceived tinkering as a way of learning citizens some skills which are usually only reserved for these technical specialists: "*Making.. being able to make it yourself. Being able to make air quality sensors, work with DNA-material, start coding with children. These are all ways to get a grip on the technological society*" (Waag Society Amsterdam).

Informative

Several informative strategies could be identified that aim for increasing the transparency of data-driven practices. According to a research participant of the municipality of Utrecht, this becomes even more important as more automatic technologies are introduced such as algorithmic decision-making. One fairly obvious example was the publishing of information material that employs clear language (see Table 4) and that explains the social construction data: "*For example, we as municipality want to use health data if we get that from you, aggregated, to find out whether certain diseases or ailments are more common in our city than in other cities to base our policies on this. And that means that we would use your data on this level, combine it with that and eventually analyze them to produce these type of results. Then you have a fully controllable and transparent process. And if you as a citizen still cannot live with that, then you could go talk to the city council of course*" (Municipality of The Hague). Informative strategies were also utilized by civil society organizations to bring smart city issues under the attention of municipality officials and residents. A research participant of SETUP Utrecht, for example, developed websites like socialcooling.com, mathwashing.com and technologiebeleid.nl that clearly illustrate issues like privacy, autonomy and fairness in relation to data-driven practices.

Table 4. Examples of revealing and transparent use of language in explaining data-driven projects

Revealing	Transparent
Sniffing pole	Air quality sensors
Bang sensors	Digital microphones that register noises such as (illegal) firework
Bicycle parking sensors	Digital cameras that count the empty parking spots without storing footage

Both municipality officials and civil society organizations described the role of particular media as essential to their own awareness of smart city issues. For instance, documentaries by VPRO Tegenlicht were named as very influential in informing a wider audience about data-driven practices. A research participant of the municipality of Utrecht explained how his reading of the book Black Box Society by Frank Pasquale (2015) inspired him to further examine issues of transparency and fairness in actual data-driven projects.

Moreover, civil society organizations and to a lesser extent also municipalities and knowledge centers employed ludic and playful actions to make data-driven practices more transparent. For example, during the Rotterdam lecture 'Citizens and Governance in the Smart City' Liesbet van Zoonen described data walks that she organizes in her city. During these walks, participants were challenged to identify all kinds of points in public space where data might be assembled or applied, and then to discuss the likely purposes and social actors behind these practices. Data points could be anything from public transport check-in posts to security cameras and from ATM machines to stickers identifying Wi-Fi access. Indeed, these data walks allowed Van Zoonen to interactively disentangle parts of the socio-technical assemblages that make up data-driven practices. While currently the data walks were mostly visited by students and policymakers, Van Zoonen planned to also organize them with residents of more disadvantaged neighborhoods to make the initiative more inclusive. A different playful action was observed during the 'more data' symposium at the Netherlands Study Centre for Technology Trends. Here, SETUP Utrecht had set up a booth to welcome visitors near the entrance and immediately get their attention for a more critical perspective on big data. A playful action displayed here was a coffee machine that was able to produce a good or bad tasting cup of coffee based on the social status of your neighborhood, which was retrieved from a database of Statistics Netherlands (see Figure 4). The idea behind this action was to illustrate to visitors of the symposium how big data risk being used for separating the privileged from the marginalized, thereby leading to issues of fairness.

Figure 4. Playful project by Vincent Hoenderop of SETUP Utrecht (own photo material from the symposium 'more data' at the Netherlands Study Centre for Technology Trends).

Conclusion and discussion

The vision of a smart city that uses digital technology and big data to address urban problems has received a lot of attention in recent years (Townsend, 2014), both from academia, business and government. While often praised, it is also criticized for being dominated by a top-down approach that favors corporate power over citizen power (Hollands, 2008; Söderström et al., 2014) and risks subjugating residents to mass surveillance and control (Galdon-Clavell, 2013; Krivý, 2016; Vanolo, 2016). Still, recent interest in taking a bottom-up approach has thus far not been met with equivalent theoretical and empirical development (Cardullo & Kitchin, 2017; Hollands, 2015). This paper presented a qualitative research project on how the smart city vision becomes translated into specific data-driven practices in the five largest Dutch cities. Based on a general socio-technical framework, it was possible to examine the interrelationships between technology, social actors and institutional properties that determine the functioning of this mode of urban governance. More precisely, the goal of this study was to examine how public interests may be safeguarded in relation to smart cities' logics and issues that follow from specific data-driven practices.

The findings point out that data-driven practices operated according to three different logics: entrepreneurialism, managerialism and communitarianism. While Kitchin (2014b/2015) had already proposed a kind of distinction between data-driven entrepreneurialism and managerialism, referring to how the smart city vision conceives of digital technology as driving both economic growth and new forms of urban management, the addition of data-driven communitarianism, on the other hand, refers to the use of (big) data by local communities and civil society to address urban problems together. In line with the general socio-technical framework of this study, each logic was enacted through specific assemblages of technology, social actors and institutional properties (Fountain, 2001; Kitchin, 2014a; Orlikowski, 1992). Indeed, technologies of data assembly, analysis and application were sometimes used by IT companies for economic development towards a tech-based knowledge economy, sometimes by local government in finding evidence for new policies, optimizing management and ensuring discipline and control, and sometimes by local communities to facilitate a participative society.

Similar to previous critiques of the smart city (Hollands, 2008; Krivý, 2016), it was found that issues of dominant corporate power and risks of subjugating residents to mass surveillance and control were indeed at stake. However, it also appeared crucial to look beyond just concerns about corporate power and privacy for fully grasping the downsides of smart cities. A broad distinction was thus proposed between technical-methodological and ethical-societal issues. This not only made it possible to critically reflect on data-driven projects enacted from entrepreneurial and managerial logics, but also on practices that were enacted from a communitarian logic.

Finally, several mitigation strategies were observed to safeguard public interests. These ranged from reconfigurations in the technologies applied, social actors involved and institutional properties at hand. Next to producing and adapting technologies to automatically take into account several smart city issues, important strategies could be found in changing the legal institutional context, involving politicians that are both ambitious and critical, making specific organizational arrangements, employing citizen participation and informing relevant social actors in both serious and playful ways. Although the involvement of a city's residents can thus certainly play a role in safeguarding public interests, as widely speculated upon by scholars and policymakers alike (Cardullo & Kitchin, 2017; Hemment & Townsend, 2013; Hollands, 2015), it can only be one link in a chain of mitigation strategies.

While the comparative approach to studying numerous data-driven practices proved useful, it also has some limitations. Most importantly, it did not allow for collecting as much information about every project's unique socio-technical assemblage. A focus on commonalities risks overlooking details that can be very important to a specific project. This is why Kitchin (2015) recommended to employ both comparative designs and case studies in the study of smart cities. An interesting example for combining these two in future research would be to compare a few data-driven projects that are overall very similar, but use different technologies, involve citizens in different ways (social actors), originate from different policy domains (institutional properties) or originate from different localities (spatio-temporal context). In this way, the general socio-technical framework proposed in this paper could be tested more formally. An additional benefit to a case study design could be that research participants feel more comfortable telling about the issues they experience in full detail since a closer bond can be established before interviewing them. Another limitation to this research has been the lack of a corporate perspective. Although the position of IT companies was extensively reflected upon, taking into account their viewpoint and experiences more directly could have benefited the findings. Almost all data-driven projects involve at least one commercial party (Townsend, 2014), so future research could actually take advantage of their knowledge on the subject. This does not imply that business statements should be approached any less critically. Involving their perspective could actually even help scholars develop a better understanding of the entrepreneurial logic and formulate a more detailed critique on corporate power in the smart city. The generalizability of this study's findings beyond the specific spatio-temporal context of the five largest Dutch cities is unknown. For smaller cities in the Netherlands and cities abroad there will most likely be unique elements to their socio-technical assemblages, which could both lead to similar or vastly different conclusions. It is also suggested that future research will make a comparison between 'smart cities from scratch' like New Songdo (Sennett, 2012) and 'already existing smart cities' such as the ones from this study (Shelton et al., 2015). Finally, for a vision so focused on big data there is surprisingly little quantitative research available about smart cities (though see De Wijs et al., 2017). It is thus suggested that future research will at least employ a survey to map some of the technologies, social actors and institutional properties in a more standardized format.

Seeing cities integrate more and more advanced digital technology into their mode of urban governance, the urgency to investigate how this works out in practice as an enacted technology becomes pressing. New technological developments like virtual and augmented reality might create a completely different picture in a few years' time. Indeed, the smart city vision could be developed and implemented in myriad of ways. What citizen involvement will look like in the future may thus be very different than what it is today. In the end, the development of an economically, socially and environmentally responsible smart city will depend on how socio-technical assemblages become reconfigured to benefit us all.

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