A Sociotechnical Framework for Smart Urban Governance: Urban Technological Innovation and Urban Governance in the Realm of Smart Cities

Huaxiong Jiang, Utrecht University, Utrecht, The Netherlands

<https://orcid.org/0000-0001-6342-4546>

Stan Geertman, Utrecht University, Utrecht, The Netherlands

<https://orcid.org/0000-0002-8824-0484>

Patrick Witte, Utrecht University, Utrecht, The Netherlands

ABSTRACT

Over the past decade, the dominant entrepreneurial form of urban governance has seriously hindered the transformation of cities by neglecting the role of urban contexts in shaping governance structures and outcomes. To promote alternatives, this article presents a sociotechnical framework for smart urban governance. This framework explicitly examines the impacts of urban contexts on the sociotechnical interaction between urban technological innovation and urban governance in the realm of smart cities. Three real-world cases were used to demonstrate how the framework can be applied in different urban contexts. The results show that the alleged smartness in smart urban governance by no means implies the simple acceptance, adoption, and use of technology; instead, it needs to be conditionate. For successful smart urban governance, urban technological innovation should be effectively attuned to the wider urban actors and preexisting urban challenges (i.e., the urban governance process), with a special focus on the urban context.

KEYWORDS

Smart City, Sociotechnical Approach, Transformation of Cities, Urban Governance, Urban Technological Innovation

INTRODUCTION

Over the past decade, the notion of “smart cities” has been proposed as a way to deal with dramatically increasing urban issues (housing, crime, air pollution, traffic congestion, etc.). However, according to several authors (e.g., Grossi and Pianezzi, 2017; Hollands, 2015; Shelton et al., 2015; Lee et al., 2013), the governance of smart cities is largely in conjunction with an entrepreneurial form of urban governance. In practice, the notion of smart city is promoted by local governments to attract global capital and boost local economic growth (Shwayri, 2013). Some of

DOI: 10.4018/IJEPR.2020010101

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the most extensively elaborated examples of these initiatives—for example, Songdo Ubiquitous Eco-City (South Korea), Genoa Smart City (Italy), and Masdar (United Arab Emirates)—are places where large high-tech companies and real estate companies have dominated the planning, design, and construction of facilities and entities (Grossi and Pianezzi, 2017; Hollands, 2015; Kitchin, 2015; Shwayri, 2013). Consequently, the application of various electronic and digital technologies to cities is largely promoted by “the profit motive of global high-technology companies” (Hollands, 2015). High-tech companies typically emphasize that the adoption and implementation of new technologies will bring benefits to cities; however, this corporate vision of smartness has caused an emergence of “business-led technological solutionism” (Kitchin, 2014). In practice, various information and communication technologies (ICTs) are packaged and promoted by private sectors, whereas their substantive added value for augmenting urban operation and urban governance is far less considered.

Meijer (2016) claims that any successful smart city governance is closely related to our perception and use of technologies across the entire city. The idea is that the usefulness of technology for augmenting urban governance in the realm of smart cities can only be enhanced by studying the interaction between urban technological innovations and governance processes in specific urban contexts (Bolívar and Meijer, 2016; Meijer, 2016; Meijer and Bolívar, 2013). In this paper, urban technological innovation refers to the creation, diffusion, adoption, and utilization of new technologies. According to Cels et al. (2012), it is the social dimension that determines the meaning and function of technologies and makes them work. Hollands (2008) argues that the governance of smart cities should consider the input and contribution of various groups of people in the production of knowledge, techniques, and new technologies. It is argued that the opportunities only arise when technological solutions are developed and implemented in close collaboration with research institutes, businesses, and citizens (Chesbrough, 2006). So far, little attention has been paid to this connection. In fact, new technologies developed in smart cities have often been criticized for their negligence of the embedded governance processes (Capra, 2016; Shelton et al., 2015; Meijer and Bolívar, 2013).

The aim of the present research was to connect the two and investigate the extent to which urban technological innovations interact with urban governance in specific urban contexts and produce alternatives for the governance of smart cities. Special emphasis was put on the impacts of urban contexts on the sociotechnical interaction between urban technological innovations and urban governance. In this paper, these alternatives driven by technology interaction with urban governance are called “smart urban governance.” Thus, our attention shifted from a focus on the entrepreneurial form of urban governance, to a sociotechnical process of smart urban governance. Here, a sociotechnical method indicates that a system that is intended to be optimal should only be situated in a particular setting, and that the optimum is always the result of the sharing of the views and knowledge of people in a social process (Vonk and Ligtenberg, 2010). Thus, the usefulness of urban technological innovations in the realm of smart cities should only be integrated into an urban governance process, enabling participants or urban actors and the context specificities to determine its added value.

The following section discusses the scientific literature on urban technological innovation and urban governance in the realm of smart cities and shows how the two research areas can converge and offer new opportunities. The developed sociotechnical framework is then presented to illustrate how alternatives for the governance of smart cities (i.e., smart urban governance) can be produced. Section 3 explains the research methodology and steps. In Section 4, three real-world smart city projects are presented to account for the dynamics of technology interaction with urban governance and to reveal the resulting meanings of smart urban governance. In Section 5, the findings of the case analysis are presented. Section 6 presents the conclusion.

URBAN TECHNOLOGICAL INNOVATION AND URBAN GOVERNANCE IN THE REALM OF SMART CITIES

Urban Governance

There is a large body of literature on the meaning of urban governance. Some authors explore the use of various theories concerning power to analyze the political struggle between different actors (Obeng-Odoom, 2012), while others focus on the transformation of government institutions toward more open and inclusive processes (Nicholls, 2005). Influenced by neoliberalism, urban governance can also be understood as a form of entrepreneurialism (Harvey, 1989). Although the concept of urban governance in academia remains vague, Pierre (2005) argues that urban governance can be tailored to the real needs of cities. This indicates that the meaning of urban governance can be understood according to the specific urban context. Nevertheless, urban governance in general refers to “a range of actors and institutions; the relationships among them determine what happens in the city” (Avis, 2016:5). It involves a continuous process of negotiation and contestation over the allocation of social and material resources and political power. Throughout this paper, we use this encompassing definition of urban governance and discuss how urban governance can be adapted to deal with the governance of smart cities with the help of technology.

Urban Governance in the Realm of Smart Cities

A smart city is about integrating ICTs into various physical devices (e.g., transportation, smart living and utility) to optimize the efficiency of city operations (Batty et al., 2012). ICTs developed in smart cities range from big data, social media, and the Internet of Things, to transport systems, traffic regulation systems, and even artificial intelligence. Both researchers and practitioners have argued that these ICTs and sensor networks can be used to enhance the capabilities of current urban governance structures (Meijer and Bolívar, 2016; dos Santos Brito et al., 2015; Scholl et al., 2014; Kitchin, 2014). However, Luque-Ayala and Marvin (2015) argue that at present, a relatively exclusive set of policy, technology, and commercial interests dominate the debate on the smart city and its governance. Practical urban governance in the realm of smart cities is just a straightforward or simple extension of the neoliberal city (Shelton et al., 2015). Many smart city initiatives have been dominated by private technology developers such as IBM, Cisco, and Huawei (Jiang et al., 2019; Deakin, 2013). Large high-tech companies inherently think that the idea and vision of smart cities are transformational and affirmative. As a consequence, “the governance trend has continued with an increased emphasis on efficiency savings, privatization and the promise of a high-tech future” (Hollands, 2015:68).

For instance, POSCO Engineering and Construction, a South Korean consortium, was granted the right to partner with an American developer to plan, build, and operate the Songdo International Business District—a part of the Songdo Ubiquitous Eco-city. But a key question raised here is the extent to which this corporate entrepreneurial smart city can truly serve all citizens and promote the city’s transformation (Shwayri, 2013). Due to a lack of opportunities for citizens to engage in the creation and operation of this project, urban local government and large high-tech companies in particular dominate economic and business interests, disregarding wider social and environmental priorities. Consequently, some of South Korea’s real urban problems (unemployment, overcrowding, slums and squatter settlements, social inequality and discrimination, etc.) are largely ignored in this neoliberal urban vision (Shwayri, 2013).

In fact, the outcomes produced by the governance of smart cities are rather controversial, since the access to, use of, or impact of ICT has seldom been considered (Colding and Barthel, 2017; Przybilowicz et al., 2015). Kummittha and Crutzen (2017) argue that the prevalence of entrepreneurial urban governance leads to a technological deterministic view on smart city developments. The danger of this corporate dominance in urban technological innovation, is that such solutions are overly technocratically packaged as one-size-fits-all solutions. Technology itself has been designed as an

end—its adoption will automatically produce increased quality of life for citizens in a smart city setting. Technology developers believe that the adoption of technology can smarten a government's city management capabilities and produce ideal results for the city. However, this corporate-led techno-imaginary has seriously neglected the particular context that enables participants to define and revise the functionality of one typical technical tool (Kling, 1996). Therefore, it remains unclear whether technology can contribute positively to urban improvements.

At the same time, some authors highlight that this technology-driven approach could subject ordinary people to the complete control and authority of the government power (Krivý, 2018). For instance, the massive use of big data in crime control enhances the government's social control capabilities, but it also introduces ethical and legal concerns with regard to "discrimination, privacy, and the presumption of innocence" (Završnik, 2017). Although some authors claim that using new digital telecommunications infrastructure can empower citizens to decide what governments should do (Fung, 2015; Linders, 2012), it is apparent that this "splintering urbanism"—examining the role of urban infrastructure, especially ICT-enabled infrastructural networks, in fostering social and spatial inequality (Graham and Marvin, 2002)—might not be able to support multi-stakeholder problem-solving. According to Gabrys (2014:43), "the very responsiveness that enable citizens to gather data does not extend to enabling them to meaningfully act upon the data gathered, since this would require changing the urban 'system' in which they have become effective operators." This indicates that new forms of urban governance in the realm of smart cities should explicitly consider the sociotechnical processes, since it is the perceptions, expectations, capacities, and skills of users and the practical urban issues that determine the usefulness of technologies.

Urban Technological Innovation

As Hollands (2015) claims, the technology-driven approach to augmenting urban governance is, to a large degree, merely an attempt to create a modernist image of the smart city. It has failed to put the interests of local people at the center. Sassen (2011) argues that the large-scale utilization of technologies has an anti-urban character, since the technologies applied to drive the development of cities have not been sufficiently urbanized. If this problem cannot be solved, technology could soon become the "censored," which would be altered to command and control urban actors. To avoid this, Meijer and Bolívar (2013) state that a stronger empirical understanding of the relation between urban technological innovation and governance processes is needed. As Janowski (2015) suggests, the implementation of technology in the city should be contextualized to consider the importance of local specificities and particular settings, since it is the context that enables technology to work. Thus, the functionality to augment urban governance should be closely connected to the real needs of different urban actors and existing governance practices. This view helps to shift our awareness from a focus on the technology-driven approach, to a sociotechnical process of urban technological innovation.

In this paper, urban technological innovation is sociotechnical in the sense that technology and social settings develop in a process of mutual shaping in specific urban contexts. It involves the adoption and utilization of new technologies and also "changes in routines, collaborations, and roles of actors" in the governance of smart cities (Meijer and Thaens, 2018). To highlight the different perceived values of technology in the innovation process, the four perspectives of urban technological innovation—a technological, an instrumental, a collaborative, and a symbolic perspective—elaborated by Meijer and Thaens (2018) are referred to. Their corresponding meanings are shown as:

- **Technological value:** The acceptance, adoption, and use of technology in itself are deemed valuable;
- **Instrumental value:** The technology supports the participants in achieving their desired goals;
- **Collaborative value:** The technology builds a platform to meet other actors and develop collaborations;

- **Symbolic value:** The technology offers rationale/legitimacy to the innovation process because of the idea that technology can help build a better future.

The four perspectives indicate that the meaning of technology is not just objective, as most people think; instead, it is embedded in its social context and constructed in a sociotechnical process. The reasons for the acceptance or rejection of a technology should be connected to the social world; in other words, we must investigate how the standard of being “the best” is delimited and what individuals, groups, and stakeholders are getting involved in designating meanings to technology. Thus, relating the meaning and content of technology to the wider socio-spatial milieu is urgently needed, since it is the socio-spatial context that explains the origins of the technological brief, shapes the design and development of technological functions, and assesses the success or failure of technological implementation (Cels et al., 2012).

Why Context Matters

As mentioned, the integration of urban technological innovation into urban governance in the realm of smart cities should consider the specific urban context. Here, context refers to the circumstances or situations that form the setting for the sociotechnical interaction between urban technological innovation and urban governance processes, and in terms of which it can be fully understood and assessed. In fact, several articles have theorized and investigated the importance of contextual factors in affecting the governance of smart cities. For instance, Meijer (2016) emphasizes the hidden role of “the local cooperative knowledge potential” and “the nature of the problem domain” in shaping the technology interaction with urban actors. Bolívar and Meijer (2016) highlight the impact of factors such as “political or demographic factors, administrative cultures, and technological factors” on the structure of smart city governance. According to Lin (2018), different institutional and technological contextual factors have made smart city governance in some Western countries relate more to e-governance and e-democracy, while smart city governance in China is focused more on smart management and services. Kalathil and Boas (2010) also argue that the level of economic development will influence how technology is organized and used in ICT-enabled governance. In addition, some studies also indicate that the nature of the urban problem itself—such as the social, economic, and environmental challenges associated with urbanization—is also an important contextual factor (Lin, 2018; Meijer, 2016).

To summarize, the smart city governance research revealed six contextual factors, namely economic, political, demographic, cultural, and technological factors, and the urban problem itself. Nevertheless, Ruhlandt (2018:9) claims “the influence of contextual factors on smart [city] governance still remains unclear” and a lack of empirical studies weakens this connection. Thus, more detailed analyses of the governance of smart cities in different contexts are urgently needed (Meijer et al., 2016).

A Conceptual Framework for “Smart” Urban Governance

To examine the potential role of contextual factors in influencing smart governance arrangements, Jiang et al. (2019) developed a new model that includes two main dimensions: urban contexts and technology interaction with urban actors. They suggest that this model can be used to investigate the impacts of urban contexts on the technology interaction with urban actors and examine the resulting meanings of smart governance arrangements. In fact, the model is helpful in understanding how urban technological innovation (i.e., perceived value of technology) interacts with urban governance (i.e., actor relations) in specific urban contexts and how this interaction produces smart urban governance. Therefore, we adapted the model developed by Jiang et al. (2019) and, based on our previous analysis, created our sociotechnical framework for smart urban governance (see Figure 1).

In this framework, urban contexts are the circumstances that form the setting for the socio-technical interaction, which mainly includes six factors—economic, political, demographic, cultural and technological factors, and the urban problem itself. The socio-technical interaction is the

Figure 1. A sociotechnical framework for smart urban governance

bidirectional influences between urban governance processes and urban technological innovation. Smart urban governance is the outcome of the socio-technical interaction. The combination of these three dimensions suggests four potential relations:

1. The sociotechnical interaction between urban governance and urban technological innovations is potentially influenced by urban contexts;
2. The potential effect of the urban context on sociotechnical interaction relies on the interaction between urban technological innovation (perceived value of technology) and urban governance (actor relations);
3. The sociotechnical interaction in the realm of smart cities would potentially produce smart urban governance;
4. A potential feedback effect of smart urban governance on the urban contexts.

In fact, the conceptual model in Figure 1 reflects the possible linkages between urban contexts, the sociotechnical interaction, and smart urban governance. The following section applies this framework in practice and explores the extent to which the possible linkages take place in real-life smart city projects.

METHODOLOGY

On the basis of an extensive review of index systems, research reports, key literature, national and local policies and documents, three empirical smart city projects in three countries (i.e., Mongolia, China, and the Netherlands) were selected to explore the added value of the framework. These three cases are: 1) Smart Ulaanbaatar Program, Mongolia; 2) Hangzhou City Brain Project, China; 3) and Amsterdam Smart City, the Netherlands. The primary reason for selecting these three cases is that they differ in their development stage and are in different urban contexts. For instance, stages of urbanization in these three countries vary considerably, which makes a great deal of difference with regard to the most pressing problems faced by these cities. Then, the different political systems in these three countries also made it interesting to see how context-specific characteristics led to different sociotechnical interactions and different forms of smart urban governance.

Data for these three cases was mainly gathered from governmental portals as well as smart city project websites via two search engines, namely Google and Baidu (China's largest search engine).

We also used documents from other resources that we reviewed, such as relevant published reports, academic literature, digital newspaper archives, and project policy reports that actually portray substantive discussions on these three cases. We selected five academic articles, 10 government policy documents, 16 web publications and 10 newspaper articles to gain a full understanding of the sociotechnical interaction between urban governance and urban technological innovations. We then created a coding scheme capable of representing Figure 1, which mainly includes dimensions of urban contexts, key urban actors and their responsibilities, technologies and their perceived values, technology interaction with urban actors and relevant outcomes, and feedback effects on urban contexts.

Since these documents are the result of deliberations by governments, experts, and journalists, a close discursive analysis of these documents was well suited to interrogate the sociotechnical framework for smart cities. According to Keller (2011), the central focus of discourse analysis is the expression of discourse order and the establishment of a discourse structure. It involves understanding texts to “gain information regarding how people make sense of and communicate life and life experiences” (Allen, 2017, p. 1753). The key for discourse analysis is that the study of discourse meanings should be related to the social conditions and their changes, since a larger social structure influences the discursive construction of meanings. In this paper, aspects of discourse analysis rely mainly on the coding texts of the identified documents (Lin, 2018). A particular focus is how urban context influences the sociotechnical interaction and produces different forms of “smart” urban governance.

EMPIRICAL EVIDENCE FOR SMART URBAN GOVERNANCE

Smart Ulaanbaatar Program, Mongolia

In the 1980s, Ulaanbaatar—Mongolia’s capital and largest city—was vibrant. Since then, however, severe droughts, harsh winters, and over-grazing, along with the end of Soviet state support, have caused more than 600,000 nomadic herders to leave their semi-arid grassland and migrate to Ulaanbaatar (Kingsley, 2017; Bassett, 2010). Buildings, streets, and infrastructure in the city have deteriorated severely and green parks and public spaces have been replaced by self-built *gel* (or yurt) houses. Consequently, the fast and disorderly expansion of the urban fringe has posed Ulaanbaatar serious urban challenges, such as a shortage of energy supplies, soil contamination, and a lack of urban infrastructure and housing (Kingsley, 2017) (Figure 2).

To deal with these urban problems, in 2014 Ulaanbaatar City Municipality launched the Smart Ulaanbaatar Program (Batchuluun, 2014). The program was designed to have a broader focus on governance, economy, service, environment, people, and wellbeing, but its foremost purpose is to exhaustively digitalize Ulaanbaatar’s infrastructure and improve the internet penetration (Naranmandakh, 2018). Reports show that both the national government of Mongolia and the city government have committed themselves to staying ahead of the curve and applying ICT innovations to advance governance reform and provide better services to the citizens. However, the country’s poor technological capability remains one of the major constraints to its efforts to achieve the desired goals (Theunissen, 2015). Therefore, this program relies heavily on international high-tech companies.

One of the most important partnerships was built with Cisco to develop the Smart Ulaanbaatar Program Solid Infrastructure Master Plan. The aim of this plan was to provide technological solutions for a data center, an emergency response center, network and information infrastructure, and a monitoring system. However, the process of urban technological innovation entailed studying other international smart city models and then developing the smart city solutions that would be introduced in Ulaanbaatar (Byambadorj, 2016). Besides Cisco, The Asia Foundation was also invited to support Ulaanbaatar’s municipality in the areas of governance and service delivery (Theunissen, 2015). Their efforts mainly focused on processes of digital cartographic production. For instance, the foundation established the community mapping website as an interactive resource for citizens and city officials to find information and download maps (Norovsambuu et al., 2013). Over 150 land demarcation

Figure 2. Urban infrastructure challenges in Ulaanbaatar (Source: <https://www.theguardian.com/world/2017/jan/05/mongolian-herders-moving-to-city-climate-change>)

maps were digitalized to resolve the problem of land permits and issuance. The Chinese company Huawei also joined, as an important equipment provider, and delivered connectivity in some remote areas of the city (Huawei website, n.d.).

In this project, both the national government of Mongolia and the government of Ulaanbaatar have strong intentions to engage in the process of urban technological innovation. However, the severity of the various challenges posed by rapid urbanization and Mongolia's weak technological basis have prompted the Ulaanbaatar government to build partnerships with foreign tech companies. This has led to a situation in which the introduction and implementation of urban technological innovations are almost entirely controlled by these companies. The Ulaanbaatar government thought that the acceptance, adoption, and dissemination of urban technologies would automatically contribute to the effective use of the urban environment, the efficient consumption of the city's resources, and the improvement of service delivery. However, Ulaanbaatar's demographics have negatively influenced the substantive use of these new digital urban infrastructures and services. According to Statista (n.d.), only 23.7 percent of Mongolia's population had access to the internet in 2017. Low digital literacy, especially among people living in the self-made *ger* houses, has prevented disadvantaged groups from gaining access to the urban basic services. Consequently, the so-called smart urban governance in Ulaanbaatar is more or less about government of a smart city via the acceptance and use of privately controlled technologies to digitalize the city's infrastructure.

In fact, the governance of Smart Ulaanbaatar Program is by no means smart, since the government and private companies focus too much on the technological value of urban technological innovation. The lack of internet literacy among nomadic groups, which make up the majority of Ulaanbaatar's urban population, makes it difficult for them to benefit from this project. As a result, there is no clear indication about the extent to which the original goals (public housing, emergency services, social welfare, food subsidies, etc.) of the Smart Ulaanbaatar Program can be achieved. Although

technology has been increasingly recognized and perceived as an important enabler of urban governance innovation, urban development, and service delivery in Ulaanbaatar (Byambaakhuu, 2017), an insufficient consideration of demographic characteristics in the governance process has largely made the intended outcomes less approachable. Thus, the feedback effect, according to Sanjaajamts (2018), shows that the Ulaanbaatar government should re-examine the urban context, especially the large number of nomadic groups living in the city, for effective urban development in the future.

Hangzhou City Brain Project, China

Rapid economic development has led to an increase in Hangzhou's population from 1.14 million in 1980 to 9.46 million in 2017 (Hangzhou Statistical Yearbook, 2017). Influenced by this, the number of motor vehicles in Hangzhou reached 2.44 million in 2017, with an annual net increase of 276,000 (Hangzhou Statistical Yearbook, 2017). The per capita ownership of motor vehicles in Hangzhou is much higher than in other large Chinese cities, such as Beijing, Shanghai, and Guangzhou, and this has caused serious traffic congestion. However, an institutional defect of traditional Chinese urban governance whereby traffic management is dominated by government organizations, has made the public department incapable of handling the various traffic issues, such as longer trip times, slower speeds, and longer queues (Su, 2017). Hangzhou is home to Alibaba (the world's fifth-largest internet company by revenue) and one of the most influential hi-tech innovation centers in China, and its government wants to transform its urban governance by leveraging its technological advantages.

The Hangzhou government along with Alibaba proposed the concept of City Brain to solve the city's traffic congestion by collecting, processing, and analyzing big data. The idea behind City Brain is that urban traffic congestion is similar to human diseases, which need diagnosing. The congestion requires a comprehensive understanding of the state of traffic operations by examining the symptoms of traffic infrastructure (traffic flow, congestion index, delay index, main road speed, expressway speed, etc.) (Alibaba Cloud website, n.d.). A large number of artificial intelligence (AI) technologies (e.g., visual/sound capture, machine learning platforms, speech recognition) should be incorporated into cities. Then, by creating a cloud-based system in which large amounts of traffic and mobility data are gathered and processed by algorithms in supercomputers, an effective traffic management platform can be built. In practice, two key urban contextual factors have influenced the sociotechnical process.

First, China has top-down political institutions and is dominated by government-led approaches (Lin, 2018). Influenced by this political situation, the Hangzhou government played a leading role in the project by, for instance, establishing a new organization (Hangzhou City Brain Construction Leading Group) that integrates multiple public sectors (e.g., public security, traffic management department, planning and natural resources department, and finance department) to guide the construction of the project. Second, due to the extensiveness of this project, City Brain requires the presence of high-tech companies. Thus, various private sectors (e.g., Alibaba, Hikvision, and Foxconn) and research institutes (e.g., Zhejiang University and Zhejiang University of Technology) were invited to carry out relevant research and development (R&D) work, namely planning, designing, developing, and implementing the program. Attentively, Alibaba developed the entire City Brain software platform (Figure 3) (Alibaba Cloud website, n.d.).

A "three-step" strategy was proposed to integrate City Brain into Hangzhou's current urban governance (Tencent website, 2018). So far, two phases have been successfully implemented. In the first phase, City Brain 1.0 was launched in some pilot districts in Hangzhou, in order to investigate how this system could be adapted to different traffic situations and how local governments can engage in this experiment process and build their basic technology skills, such as word processing, image analysis, and database skills. Then, driven by joint efforts by the government, universities, and enterprises, City Brain was considerably improved in the second phase (Hsu, 2018). It was transformed into a more cloud-powered and AI-driven urban traffic management system and extended to the whole city in 2018. This 2.0 platform can predict traffic flows, detect accidents, and provide

Figure 3. City Brain for traffic management in Hangzhou (Source: <https://www.alibabacloud.com/et/city>)

instant feedback; as a consequence, its instrumental value was highlighted to help traffic managers make decisions based on the real-time data. In the third phase, City Brain 3.0 will be developed into a comprehensive platform to effectively govern various other city events (community and public safety, criminal activities, fire emergencies, floods, etc.).

In this project, the political institutions, heavy traffic congestion, and Hangzhou’s technological strength constitute the urban context. Influenced by this context, the Hangzhou government has been actively engaged in promoting new governance approaches to deal with the traffic congestion. Private companies and research institutes, such as Alibaba and Zhejiang University, were invited to design and develop relevant AI technologies. Although it seems that the governance of the City Brain project satisfies the triple helix model proposed by Etzkowitz and Leydesdorff (2000), the Hangzhou government in fact has played a leading role due to its dominant political power. As a result, the instrumental value of City Brain is strongly highlighted by the Hangzhou government to augment Hangzhou’s urban administration. Smart urban governance in Hangzhou is about building smart administration with a government-led triple helix model of urban technological innovations, aimed at optimizing the traffic system.

Smart urban governance in Hangzhou has not only improved the government’s administrative capabilities (e.g., more intelligent and responsive to traffic congestion), but also provided better services and urban data to both enterprises and individuals (Beall, 2018). In addition, a large number of enterprises have greatly improved their innovation capabilities through participation. Despite all the positive effects, City Brain has also caused some controversies and concerns. Since universities and big high-tech companies in China usually have a close relationship with the government, this relatively collusive relationship largely excludes citizens from the sociotechnical process. Thus, residents’ ideas, opinions, and knowledge and the collaborative value of urban technological innovation may not be well reflected in this project. In addition, the physical and policy changes resulting from City Brain have had negative impacts on the urban residents. For instance, a recent survey conducted by Chinese

state broadcaster CCTV and a tech firm Tencent (TCEHY) shows that nearly 80% of respondents are concerned with the impact of City Brain on their privacy (Toh and Erasmus, 2019). As Ho (2017) highlights, “the neoliberal-developmental logics of the state [to a large degree] facilitate authoritarian consolidation.” Thus, for smart urbanism to effectively enrich people’s everyday lives, a more participatory approach to urban challenges should replace the technocratic governance (Ho, 2017).

Amsterdam Smart City

Amsterdam—the capital of the Netherlands—is home to more than one million people. However, over the past two decades a large number of foreign immigrants have contributed to Amsterdam’s rapid urban growth (Statistics Netherlands website, 2019), putting a huge amount of pressure on supplies of urban water, housing, infrastructure, education, medical care, and so on. Then, located below sea level, urban safety of Amsterdam has been seriously threatened by recent climate change. Consequently, both the government and the citizens of this city are aware of how fragile Amsterdam can be. Studies show that to deal with this challenge, an ongoing digital revolution and advances in digital technologies have been the city’s top priority since 2007 (Mora and Bolici, 2015). This led to the creation and development of the Amsterdam Smart City project as the primary enabler of the city’s transformation.

The aim of the project is to build an “innovation platform that brings together proactive citizens, innovative companies, knowledge institutions and public authorities to shape the city of the future” (Amsterdam Smart City website, n.d.). Studies show that three important urban contexts have played a crucial role in influencing the sociotechnical interaction between urban technological innovation and urban governance in Amsterdam (Henriquez, 2018; Capra, 2016; Mora and Bolici, 2015; Lee and Hancock, 2012).

First, Amsterdam is vulnerable to climate change and a rising sea level, and the content of Amsterdam Smart City is closely related to the city’s climate program, which is aimed at clarifying Amsterdam’s climate goals and reduce local energy consumption (Mora and Bolici, 2015). Influenced by this, the development of technology is largely focusing on dealing with Amsterdam’s actual urban ecological problems. For instance, various energy saving technologies have been tested in climate-related living labs (Jacobson, 2012). These technologies have contributed to Amsterdam’s smart grids and smart meter systems that are intended to save energy and create new opportunities for Amsterdam’s electricity consumption transformation.

Second, the Netherlands’ democratic system in conjunction with government transparency is another key urban context that influences the sociotechnical process of this project. As people with varied skills, knowledge, and entrepreneurial capabilities have come together in one place, inclusive institutions and open government can effectively integrate human and social capital into the process of collective problem-solving. For instance, the Amsterdam city government built the Amsterdam City Data platform, to provide free access to various urban datasets (traffic data, land value and ownership information, topographical and address data, healthcare data, etc.) (Gemeente Amsterdam website, n.d.). To create a hyper-connected hub for technological innovations and entrepreneurs, in 2015 a collaboration between the Municipality of Amsterdam and 250 stakeholders launched ‘StartupAmsterdam’ (StartupAmsterdam website, n.d.). In this ecosystem, ordinary people, private firms, research institutes, and other organizations with an interest in technology and digital and electronic art, can come together to collaborate on technological innovation via the online community and various offline events. Within two years, this led to the launch of a record-breaking 1,500 startups (Macpherson, 2017).

In addition to the aforementioned urban contexts, characteristics of Amsterdam’s demographics also influence the sociotechnical process of the project. Internet literacy in the Netherlands is relatively high and this further contributes to “the availability of relevant knowledge among citizens and stakeholders, and the willingness to contribute this knowledge to collective problem-solving” (Meijer, 2016:75). Compared to the previous two cases, a strong awareness and intention to engage among

Amsterdam's citizens provide test-bedding sites for the early adoption of technology and solutions, especially environmentally friendly industries and environmentally responsible practices (Henriquez, 2018). This further contributes to the crystallization of the proactive sociotechnical interaction as innovation culture. The best examples of this innovation culture are the various innovation-related festivals. For instance, the 'We Make The City' festival—which enables researchers, students, entrepreneurs, policymakers, artists, civil servants, and active citizens to come together to discuss and debate urgent urban issues (e.g., affordable housing, climate change, quality of life and safety, mobility and division, healthy living)—is regarded as an anchor event for the Amsterdam Smart City program (Figure 4) (We Make The City website, n.d.).

What we observe in this project is that vulnerable ecological system, democratic system, high internet literacy, and strong awareness of civic engagement in Amsterdam constitute the main urban contexts. Spearheaded by the government, various actor constellations (e.g., public–private partnerships, self-organization, private–university cooperation, community-based governance) are able to contribute their knowledge and ideas to cultivating open and smart ecosystems for the governance of urban technological innovation. For the city government and private companies, this open innovation platform ensures that the citizens' skills and knowledge can be effectively leveraged to strengthen Amsterdam's innovative capabilities and improve Amsterdam's urban and ecological resilience. For citizens, technology-enabled participation means they are no longer regarded as only recipients or customers of a service; instead, they can co-produce or co-create the city. In this process, urban technological innovation not only realizes its technological and instrumental value (e.g., smart grids and smart meters), but is also integrated into Amsterdam's urban governance and achieves its institutionalized collaborative and symbolic value (e.g., We Make the City). Consequently, smart urban governance in Amsterdam is about building various open innovation spaces for smart urban collaboration, aimed at integrating urban technological innovations into people's daily lives.

By following a sociotechnical framework to become smarter, the Amsterdam Smart City has become one of Europe's leading smart cities. In 2016, the European Commission declared the city to be the European Capital of Innovation (The European Commission website, n.d.). Indeed, smart urban governance in Amsterdam has succeeded in improving its innovation environment and the quality of people's lives. Amsterdammers do not simply apply technology to create a contemporary environment with impress-all and technology-pushed intelligent settings; what they do is to incorporate the technology into their daily lives and treat it as their cultural heritage and tell the story of who they are, where they are now, and where they want to be in the future.

Figure 4. We Make the City festival (Source: <https://blog.fab.city/urban-conference-91d4abc1ede1>)

FINDINGS

Table 1 summarized how the key dimensions (i.e., urban contexts, urban governance, urban technological innovation, smart urban governance, and feedback) of Figure 1 were treated and examined in the three cases. Based on the summary, several findings can be identified.

First, analyses show that the urban contexts in the three cities have a different influence on the formation of actor relations, the perceived values of technology, and their interactive relationship. For instance, although the Ulaanbaatar government fully intended to get involved in the governance of the Smart Ulaanbaatar Project, the severity of the urban challenges combined with Mongolia's weak technological basis have prompted it to build partnerships with foreign tech companies. The adoption and use of privately controlled technological innovations are the Ulaanbaatar government's contribution to the governance of smart cities. In Hangzhou, the top-down political institution, heavy traffic congestion, and the city's technological strength produced a government-led triple helix model of urban technological innovation for governing the traffic issue. Citizens and their concerns are largely excluded from this project. Finally, in Amsterdam, vulnerable ecological system, democratic system, high internet literacy, and strong awareness of civic engagement have facilitated the building of various open and collaborative platforms for different urban actors to participate in the governance

Table 1. Summary of the three cases

Dimensions / Cases	Smart Ulaanbaatar Program, Mongolia	Hangzhou City Brain Project, China	Amsterdam Smart City
Urban contexts	<ul style="list-style-type: none"> • Mass immigration of nomadic people into Ulaanbaatar • Low technological basis 	<ul style="list-style-type: none"> • Top-down political institution • Heavy traffic congestion • Technological basis 	<ul style="list-style-type: none"> • Vulnerable ecological system • Democratic system and government transparency • High internet literacy and strong awareness of civic engagement
Urban governance	<ul style="list-style-type: none"> • Public-private partnership 	<ul style="list-style-type: none"> • Government-led triple-helix model (i.e., government, private sector, and universities) • Exclusion of citizens 	<ul style="list-style-type: none"> • Multiple forms of urban governance (e.g., self-governance, network governance, and government-led)
Urban technological innovation	<ul style="list-style-type: none"> • Private-led technological innovation • The adoption of the technology itself as value • Symbolic value 	<ul style="list-style-type: none"> • Government-led triple-helix model of urban technological innovation • Strong instrumental value for government and market parties • Technological and symbolic value 	<ul style="list-style-type: none"> • Various living laboratories • Start-up ecosystems for innovation • Institutionalized collaborative and instrumental value • Technological and symbolic value
Smart urban governance	<ul style="list-style-type: none"> • Government of a smart city via the acceptance and use of private-controlled technologies to digitalize city's infrastructure 	<ul style="list-style-type: none"> • Smart administration with a government-led triple helix model of urban technological innovation, aimed at optimizing the traffic system 	<ul style="list-style-type: none"> • Building various open innovation spaces for smart urban collaboration, aimed to integrate urban technology innovations into people's daily life
Feedback	<ul style="list-style-type: none"> • Improved awareness of technological potentials • To re-examine the urban contexts, especially the low internet literacy among nomadic groups 	<ul style="list-style-type: none"> • Congestion relief • Enhanced government control • Privacy concern • To re-examine the needs from citizens 	<ul style="list-style-type: none"> • Improved urban and ecological resilience • Democracy and participation enhancement • Fostering an innovation ecosystem

process and to contribute their knowledge to shape urban technological innovation and the urban spatial environment.

Second, the dynamic sociotechnical interactions have indeed produced different modes of smart urban governance. In Ulaanbaatar, smart urban governance is about the government of a smart city by adopting privately controlled technologies to digitalize the city's infrastructure, whereas in Hangzhou smart urban governance focuses on smart administration to optimize traffic management. In Amsterdam, smart urban governance is more concerned with creating open innovation spaces for smart urban collaboration, aimed at integrating technology into people's daily life. However, it should be noted that the smartness of the previous two smart urban governance modes has been restricted largely. The sociotechnical process in Ulaanbaatar is largely shaped by international high-tech companies, whereas in Hangzhou the government plays a more dominant role in terms of decision-making processes and the implementation of technology. The successful sociotechnical framework for smart urban governance is nicely illustrated by Amsterdam Smart City. In this project, different urban actors can contribute their knowledge and ideas to urban technological innovation, and in turn urban technological innovation increases diversity and cross-professional collaboration. This case supports the arguments made by some authors that for successful smart urban governance, the urban governance structure should "craft new forms of human collaboration" (Meijer and Bolívar, 2016: 392) by "linking initial enthusiasm based on technological and symbolic value to the long-term dynamics of institutionalized collaboration and instrumental value" (Meijer and Thaens, 2018:365).

Third, the outcome of the sociotechnical interaction (i.e., smart urban governance) has an impact (i.e., feedback) on the urban contexts. For instance, the Smart Ulaanbaatar Program requires a re-examination of the urban contexts that were not explicitly considered in the previous phase. In Hangzhou, the introduction of City Brain has further enhanced the government's political control. In contrast, the success of smart urban governance in Amsterdam has not only reduced its urban problems, but also fostered its collaborative environment for urban future innovation.

CONCLUSION

It has been argued that urban governance is being connected to ICT-enabled government and urban technological innovation to make cities smarter (Meijer and Bolívar, 2016). This paper advances this argument by presenting a sociotechnical framework for smart urban governance to incorporate urban technological innovations with urban governance in the realm of smart cities. This framework is sociotechnical in the sense that urban technological innovations are intertwined with urban governance processes within the specific urban context. On the basis of an extensive review of index systems, research reports, key literature, national and local policies and documents, three real-world cases were used to validate this conceptual framework.

Our analyses show that the urban contexts in different cities indeed have a different influence on the sociotechnical interaction and produce different "smart" urban governance modes. However, the alleged smartness in smart urban governance by no means implies the simple acceptance, adoption, and use of technology; instead, it needs to be conditionate. The comparative study of the three cases shows that a comprehensive consideration of the urban context and a wider focus on the real needs of different urban actors (as in Amsterdam Smart City) can effectively integrate urban technological innovation into urban governance and produce smart urban governance. Compared to traditional urban governance, smart urban governance in Amsterdam nicely illustrates how technological solutions to urban problems can be "developed and implemented in close collaboration with research institutions, business, and groups of—or even individual—citizens" (Meijer and Thaens, 2018: 364).

Thus, for successful smart urban governance, urban technological innovations should be effectively attuned to the wider urban actors and preexisting urban challenges (i.e., the urban governance process), with a special focus on the urban context. Only through such processes can the value of urban technological innovation (i.e., technological, instrumental, collaborative, and symbolic

values) be fully achieved and can the knowledge and ideas of different urban actors be reflected in urban technological innovations. However, it is worth noting that the comparison of the three cases just provides a positive reference. As cities in different societies face different developmental stages and transitions, it is vital to identify approaches to sociotechnical governance suitable for their own contexts. In fact, opportunities for or barriers to the sociotechnical interaction are not only created or overcome by direct action; they are also mediated by the context-specificities. Therefore, the implications for urban policymaking and planning are obviously case-dependent. In the future, it will be useful to build further on the findings of this article and conduct policy- and practice-based evaluations of smart urban governance. This could help us to understand how to make the most of the existing opportunities for smart urban governance and how to maximize its societal value in specific urban contexts.

ACKNOWLEDGMENT

The authors thank the three anonymous reviewers for their very helpful suggestions that stimulated substantial improvements to earlier versions of this paper. Financial supports from the China Scholarship Committee (Grant No. 20160601386) are gratefully acknowledged.

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Huaxiong Jiang is a PhD scholar at the department of Human Geography and Planning, Utrecht University. He is currently working on a 'Social Urban Transitions' program concerning the theorization of Smart urban governance and its application. h.jiang@uu.nl

Stan Geertman is a Professor of Planning Support Science and Chair of Spatial Planning at Utrecht University. He has published widely in both national and international journals and has published a range of (editorial) books. Since 2013 he has been the elected Chair of the International Board of Directors of CUPUM. S.C.M.Geertman@uu.nl

Patrick Witte is an Assistant Professor in the department of Human Geography and Planning, Utrecht University. He is currently working on smart urban governance, infrastructure planning and regional economic development within the framework of the research program 'Economic Urban Transitions.' P.A.Witte@uu.nl