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ORIGINAL ARTICLE

Smartening urban governance: An evidence-based perspective

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Abstract

This paper presents a framework that provides guidelines on how information and communication technology (ICT) can create added value to smarten urban governance. Furthermore, the framework was applied to measure and interpret the added value of ICT functionalities for governance practice, based on an international questionnaire (268 respondents) and in-depth expert interviews (12 experts). For improving governance processes and handling related urban problems, the results suggest that differentiated strategies should be employed. In this way, the use of ICT in smart planning can realize its full potential—and 'smartening' urban governance can be achieved in specific contexts.

KEYWORDS

added value, governance processes, ICT, smart city, urban problems

JEL CLASSIFICATION

O32; R58

1 | INTRODUCTION

Over the past decade, the rapid development of newly emerging information and communication technologies (ICTs) (e.g., big data, Internet of Things (IoT), social media, cloud computing) in the realm of smart cities has been proclaimed as having the potential to transform traditional urban governance into "smart" governance (Jiang, Geertman, &

Witte, 2019a, 2019b; Jiang, Geertman, & Witte, 2020; Ruhlandt, 2018; Webster & Leleux, 2018). As discussed in the literature, this can be accomplished in at least two ways. First, advances in ICTs facilitate the collection, processing, and storage of big data in forms like sensor data and public and private records. The increased amount of data can provide valuable information and evidence for policy-making (Kitchin, 2014). Second, smart ICTs open up the governance process and enable different stakeholders to access the public policy-making cycle (Scholl & Scholl, 2014; Webster & Leleux, 2018). Through ICT-enabled interactive dialogues, communications, debates, and social networking, it is expected that urban problems and the real needs of individuals and communities can be better clarified and defined (Verrest & Pfeffer, 2019). According to Janssen and Helbig (2018), by continually expanding data sources and enlarging political participation, technological innovations will, in the long run, both help to alter the way that policy-makers and citizens engage with each other and promote new and innovative forms of urban governance.

Despite the potentials, the full capabilities of newly emerging smart technologies to generate a transformative governance praxis or enable constructive problem-solving activities have not been realized (Ferro & Osella, 2017). Thus, the value of technological innovations in improving urban governance has been largely restricted. Critics contend that the smart approach to solving profound urban problems is primarily supported by large high-tech companies that have substantial technical capabilities and financial resources (Hollands, 2015). ICT investments and applications in many smart city initiatives appear to be intricately linked to the promotion of big business interests (Shelton, Zook, & Wiig, 2015). In that, local governments often treat the acceptance and adoption of ICTs as applying smartness to urban problem-solving. However, such corporate-led and policy-driven digital infrastructure developments often lead to a discrepancy between the support capabilities and the demand from users and governance practices (Jiang et al., 2019a). Whether the implemented ICTs are actually useful and effective in handling urban challenges needs to be carefully examined (Verrest & Pfeffer, 2019). In fact, it appears that the application of ICTs is not well suited to facilitate an effective shift of power, institutions, and improved relations between government and non-state actors (Cardullo & Kitchin, 2019).

Hollands (2015) criticizes this corporate-led, technology-driven approach to smart cities, referring to it as a "one-size-fits-all" strategy that emphasizes the uniformity of the solution rather than relating it to specific, tailored functional support. A range of authors argue that the improved role of ICTs in governing smart cities requires input and contributions from various groups of people, as well as an increased awareness of the value of technology as a means to an end (Ruhlandt, 2018; Webster & Leleux, 2018). This implies that it is more important to focus on "the long-term dynamics of institutionalized collaboration and instrumental value" (Meijer & Thaens, 2018, p. 363). As Ferro, Caroleo, Leo, Osella, and Pautasso (2013) assert, technological innovations are considered valuable only to the extent to which they can achieve a set of goals that are recognized as being of intrinsic value for either society or a specific group of stakeholders. Therefore, Meijer and Bolívar (2016) argue that the potential of ICTs to improve urban governance should be part of a complex process of institutional change and the acknowledgement of the political nature of appealing visions of socio-technical governance.

Other authors also emphasize that tools and technologies for governing smart cities must start with the "city," matching different types of "smartness" (technologies, tools, and applications) with different types of urban functions in specific contexts (Stratigea, Papadopoulou, & Panagiotopoulou, 2015; Verrest & Pfeffer, 2019). In other words, a redefined role of technology "should be grounded in places—actually existing cities—with their specific populations, resources and problems" (McFarlane & Söderström, 2017, p. 313). Rather than leaving technologies, tools, and applications to the corporate and political elites, taking the "urban" into consideration indicates an urban social process of technological innovation in improving urban governance. More recently, Jiang et al. (2019b) proposed an urban planning perspective on smartness to improve ICTs' capabilities for smartening urban governance in the realm of smart cities. They argue that smart urban governance should integrate technology with explicit reference to the particularities of the urban challenges at stake and the specifics of the embedding governance processes. Still, studies on how to transform urban governance into smart governance and its resulting added value are mostly lacking.

This paper combines multidisciplinary knowledge of smart urban governance and planning support science to make the key argument that technological innovations (i.e., the supply of smart ICTs) should be embedded in governance processes and attuned to urban problems to achieve their added value in smartening urban governance. To help explain the argument, the following research question was formulated: "How can smart ICTs be transformed into added value in smartening urban governance?" Here, added value means the usefulness of an ICT tool to help the participants to achieve their specific urban governance objectives. It offers urban governance problem-solvers a new dimension, enabling them—with the help of ICT—to innovate decision-making processes and find action-oriented solutions.

2 | SMARTENING URBAN GOVERNANCE: A CONCEPTUAL FRAMEWORK

2.1 | ICTs in smart cities: opportunities for urban governance

The smart city concept has been adopted as a policy priority in many countries. It is argued that by integrating smart ICTs and various physical devices connected to the IoT network into urban functions, it provides creative solutions to the challenges of economic growth, social justice and environmental problems in cities (Haarstad & Wathne, 2019). It should be noted that there is no commonly agreed upon definition of "smart" cities. For instance, Hollands (2015) points out the self-gratulatory nature of the smart city label and asserts that smart cities are too dependent on big data and ICT applications. Kourtit, Nijkamp, and Steenbruggen (2017) argue that smart cities should focus on developing productive interactions between networks of urban actors (McFarlane & Söderström, 2017; Meijer & Bolívar, 2016). More recently, Wolf, Borges, Marques, and Castro (2019) showed that the achievement of a smarter city relies more on the ability to increase the flexibility and transparency of urban decision-making and promote place-based initiatives. Although many definitions of "smart city" have been identified (Albino, Berardi, & Dangelico, 2015), we adopted the comprehensive definition by Caragliu, Del Bo, & Nijkamp (2011, p. 70) to help us understand the changing and fuzzy concept: "A city can be defined as smart when investments in human and social capital and traditional transport and modern ICT infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."

The rapid development of smart cities and smart ICTs has provided various new opportunities for smartening traditional urban governance (Barns, Cosgrave, Acuto, & Mcneill, 2017). According to Nam and Pardo (2011), urban governance is increasingly being connected to disciplines that focus on technology and innovation (e.g., e-government and innovation studies). Here, "urban governance involves a range of actors and institutions; the relationships among them determine what happens in the city" (Avis, 2016, p. 5). It shows that the integration of various ICTs and digital devices into local urban government systems helps to improve the operational efficiency of urban governments and transform the role the government can play in creating a smart city. Such approaches indicate that smart city technologies can transform government from institutional conservation (i.e., traditional governance of a smart city) into more open-minded institutional structures (i.e., smart urban collaboration) (Meijer & Bolívar, 2016). According to Barns et al. (2017), it is crucial to transform and enhance the relationships between various stakeholders via smart city technologies to change how cities are governed.

In addition to the ability of smart ICTs to reshape urban governance processes, new big data can also be generated from technology-facilitated citizens to help policy-makers to analyse, model, and understand urgent urban problems (Barns et al., 2017). For instance, the rapid development of big data contributes to the emergence of big data analytics. Through the co-creation and exploration of new-found data, innovative ideas and knowledge can be produced to understand the nature of specific urban issues (Kitchen, 2014). Besides, various urban data and data platforms provide trustworthy, valid, and reliable data, which enables individuals and communities to develop and implement their own solutions to daily life problems (Jiang et al., 2019a).

Although smart ICTs can be used to support governance processes and deal with different urban problems, their potentials have not been fully realized due to the lack of an effective framework to understand and put into practice the previously argued added value of smart ICTs, namely producing new data, innovating urban governance processes, and gaining knowledge of urban issues (Ferro et al., 2013; Jiang et al., 2020). According to some literature, the smartness of ICTs is represented by the technology itself; big-tech companies around the world demonstrate their smartness by implementing a network of technological functionalities (e.g., digital devices, modules, machines, subsystems, and platforms) (Datta, 2015). However, whether the capabilities of smart ICTs can satisfy the needs of urban governance practices is only limitedly considered in most academic literature.

2.2 | A framework for smartening urban governance

To construct a framework for smartening urban governance, one has to integrate technology with explicit reference to the particularities of the urban challenges at stake and the specifics of the embedding governance processes (Jiang et al., 2019b). First, technology is envisioned as the capabilities a functionality has for supporting governance practices. Based on Vonk (2006) and Geertman (2014), three types of ICT capabilities are identified, namely *informing and communicating*, *analysing and modelling*, and *designing and visualization*. Here, informing and communicating (e.g., social media and government information management systems) is about information exchange between different persons and devices (Vonk, 2006); analysing and modelling is concerned with, usually quantitative, calculation and information production to improve our understanding of the object (Pelzer, 2017); and designing and visualization is about the perception, production, and presentation of design ideas (Geertman, 2014). Second, the urban challenges refer to urban problems that significantly influence people's wellbeing and quality of life. Campbell (1996) highlights that economic, social, and environmental problems in general constitute the core of urban sustainability challenges. Besides the general sustainability notions of social, economic, and environmental, we also identify transportation and mobility and housing as separate categories, due to their importance (Benevolo, Dameri, & D'Auria, 2016; Grigsby, 2017). Third, governance processes describe the different urban governance modes shaped by actor interactions (Pierre, 2011). Two categories of governance modes are considered: centralized processes—in which the government acts as the only or by far dominant stakeholder in urban governance—and interactive processes, in which besides government, non-state actors (i.e., market and civil society) are important and are involved too.

Furthermore, integrating functionalities into urban governance processes can be seen as an outcome (Jiang et al., 2019b). According to Pelzer (2015), the outcome can also be regarded as the perceived added value of technology. Here, the added value depends on “how well the instruments are capable of carrying out the task” (Vonk, 2006, p. 75). When functionalities are implemented to solve different problems and support the policy-making process, seven major added values can be identified to measure the outcome (Table 1). Additionally, it should be noted that contextual factors are also deemed critical for influencing the usefulness of technology (Jiang et al., 2019a; Meijer & Bolívar, 2016). Here, context is the situation and circumstance in which the application of ICT in improving urban governance is embedded. Geertman (2006) identifies six major contextual factors that influence the role of technology in supporting policy-making and planning, namely: the content of planning issues; the specific characteristics of information, knowledge, and instruments; user characteristics; the characteristics of the planning and policy process; the planning and policy style; and the political context.

Based on these ideas, a conceptual framework was developed to provide guidelines on how ICT can create added value to smarten urban governance (Figure 1). Here, the functionality linkage with urban problems and governance processes is based on the task–technology fit model, which asks “the question of whether the

TABLE 1 Different kinds of added value

Kind of usefulness	Definition
Learning about the object	Gaining insight into the nature of the planning object
Learning about other stakeholders	Gaining insight into the perspectives of other stakeholders in planning
Collaboration	Interaction and cooperation among the stakeholders involved
Communication	Sharing information and knowledge among the stakeholders involved
Consensus	Agreement on problems, solutions, knowledge claims, and indicators
Efficiency	The same or more tasks can be performed with smaller investments
Better informed plans or decisions	A decision or outcome is based on better information and/or a better consideration of the information

[a]*Source:* Pelzer, 2017.

functionality of the system in principle can do what is needed" (Nielsen, 1993, p. 24). Then, the figure shows that functionalities are incorporated into urban problems and governance processes to produce perceived added value. This whole process of application of functionalities to create added value is regarded as smartening. However, it should be noted that the level of added value produced by functionalities is related to the functionalities' linkages with urban problems and governance processes; that is, how well functionalities can solve urban problems and support governance processes. In our research, we assumed that the linkages between functionalities, urban problems, and governance processes are positively related to the added value produced by the functionalities. As some authors argue, higher adoption and use of functionalities suggest that functionalities have higher maturity levels (e.g., flexibility, simplicity, user-friendliness) (Pelzer, 2015; Vonk, 2006). Figure 1 also shows that contextual factors play an important role in influencing the role of technological functionalities in smartening urban governance.

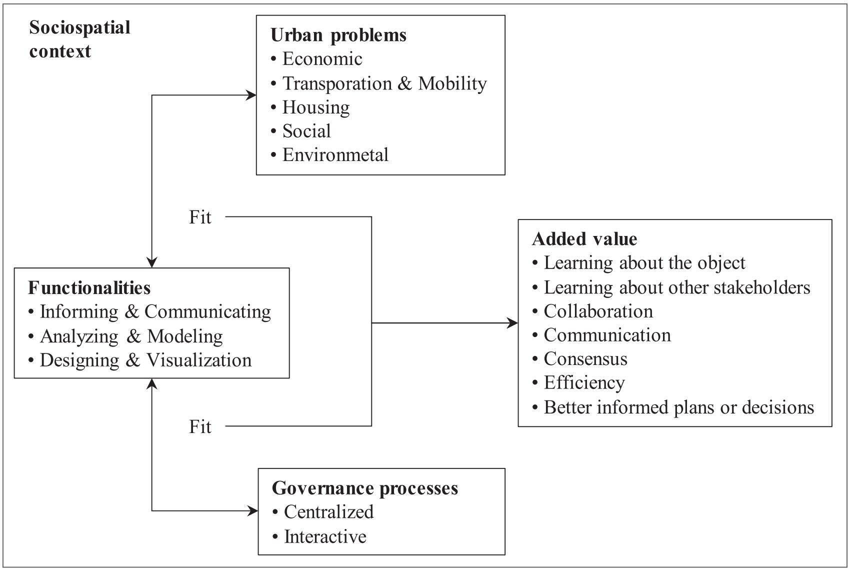

FIGURE 1 A framework for effective ICT practices in smartening urban governance

3 | METHODOLOGY

3.1 | Data collection

In-depth information about the application of ICT in smartening urban governance was gathered through an international questionnaire and expert interviews. The questionnaire was mainly distributed to the Computers in Urban Planning and Urban Management (CUPUM) research community. Using electronic and regular mailing lists, between May and September 2019, about 1,300 people worldwide were invited to complete the questionnaire. The main part of the questionnaire comprised 45 statements categorized into types of technological functionalities, urban challenges identified, involvement of stakeholders, added values, and contextual factors. Questions concerning the survey population (e.g., gender, age, profession, origin, expertise) were also asked. The respondents could respond on a 7-point scale (1 = low, 7 = high), allowing them to determine the extent to which they agreed or disagreed with each statement in the questionnaire.

Twelve internationally recognized experts were then interviewed to gain insights and opinions in terms of technological applications in smartening urban governance. The experts were from Australia, the USA, China, the Netherlands, Brazil, the UK, and Japan, and all of them had worked in the field for at least 20 years. The interviews were held between June and October 2019. After the interviews, the records were manually transcribed. By using qualitative data analysis software NVivo©, the texts were further coded and analysed to generate themes to address the research question. The analysis of the interviewed data was based on Figure 1, in order to obtain the conceptual and visionary opinions and comments of the experts on how ICT can produce added value to smarten urban governance.

3.2 | Data analysis

The analysis of the questionnaire data was based on the theoretical framework presented in Figure 1. Some of the respondents were involved in smart city projects, and this allowed them to evaluate the role of ICT in practice. As shown in Figure 2(a), a total of 268 questionnaires were returned, implying a response rate of 20.6%. Of the respondents, 175 had participated in smart city projects in which ICTs played an important role and were therefore used in our analysis. Figure 2(b) shows these 175 respondents divided into four subgroups, namely: respondents from China (53%); respondents from NAEJA (North America, Europe, Japan, or Australia) (33%); respondents from BRICS (Brazil, Russia, India, or South Africa; excluding China) (approx. 10%) and respondents from other countries (approx. 4%).

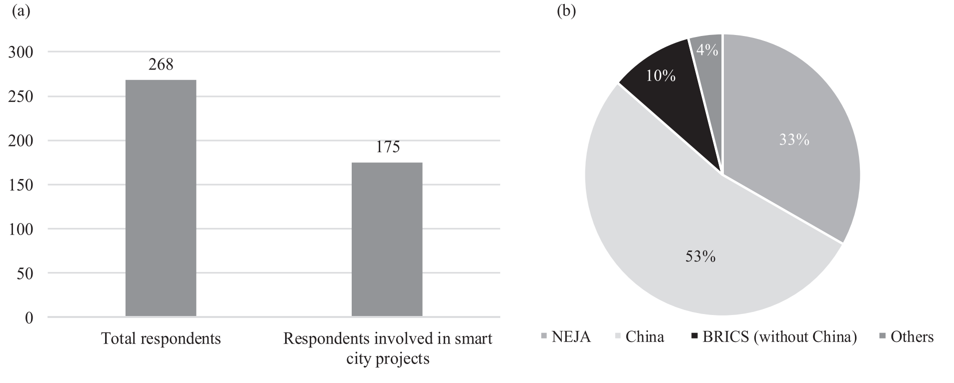

FIGURE 2 (a) Total number of respondents and number of respondents involved in smart city projects; (b) geographical origin of the respondents involved in smart city projects

The BRICS (without China) and Others subgroups were not analysed due to insufficient sampling quality. Thus, only the China and NAEJA subgroups were included in the analysis.

In terms of the data analysis, Figure 1 shows that there exist five types of "urban problems," three types of "functionalities," and two types of "governance processes." It should be noted that one smart city project can include more than one type of urban problem (not mutually exclusive) and more than one type of functionality (not mutually exclusive). However, one smart city project only includes one type of governance process (centralized or interactive, mutual exclusive). The combinations (30) of functionalities (three types), urban problems (five types) and governance processes (two types) constitute the basic unit of analysis (see Figure 3). In that we measure the frequency of occurrences of combinations of these three dimensions to describe their linkages.

Second, the indicated added value of each type of functionality in a combination of functionalities, urban problems, and governance processes was calculated by obtaining an average score. The average added value score of each type of functionality was then compared with the frequency of occurrences of combinations (the linkages) to identify their possible relationship. Additionally, a simple linear regression model was applied to statistically test the relationship. The purpose of this step was to see whether a higher frequency of linkages between functionalities, urban problems, and governance processes would result in a higher added value of functionalities.

Third, to further validate the results, the respondents were divided into two subgroups: respondents from China and respondents from NAEJA. This was done because China and NAEJA have large regional differences (e.g., level of urbanization rate, level of local development, political systems, and policy-making styles) and distinctive policy priorities. Therefore, research on the application of technology in China and NAEJA would help understand the different development trends of technology in smartening urban governance.

Finally, in-depth interviews with 12 experts from the field of urban governance/planning were used to interpret and validate the general findings. This helped us to build up a comprehensive picture of the application of smart ICTs in improving urban governance.

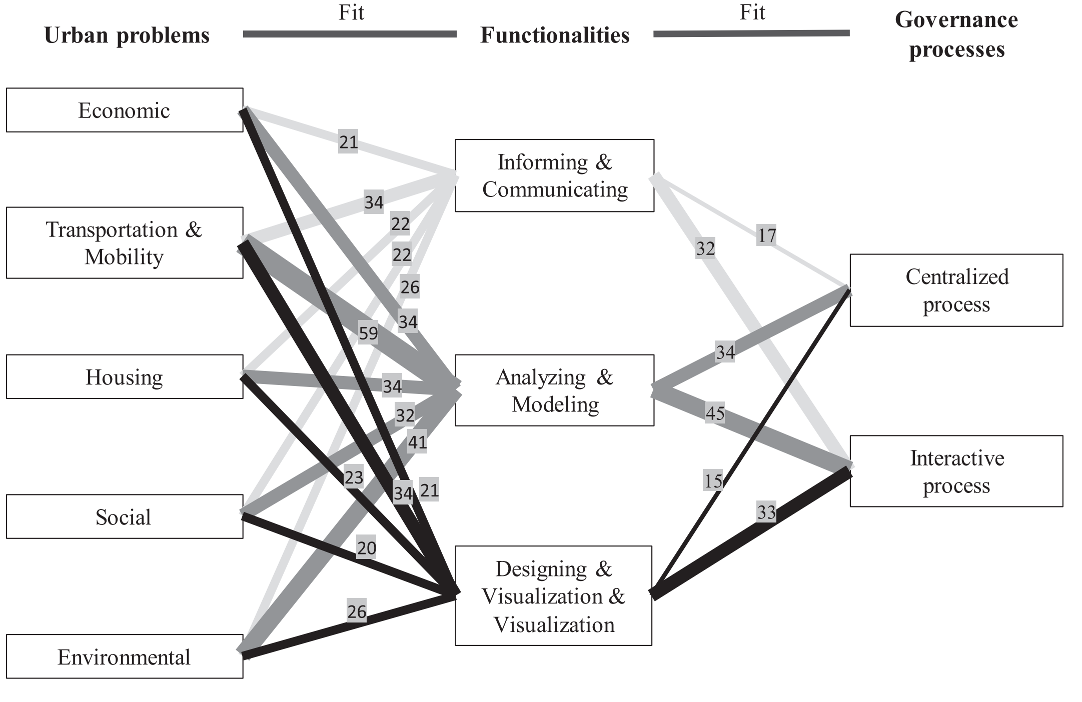

FIGURE 3 Linkages (represented by the frequency of occurrences of combinations) between functionalities, urban problems, and governance processes

4 | RESULTS

4.1 | Functionalities to smarten urban governance

4.1.1 | Frequency of linkages

The average occurrence frequency of the 30 combinations of functionalities, urban problems, and governance processes was first calculated to be able to analyse the separate frequencies of specific linkages between functionalities, urban problems, and governance processes.

The left-hand side of Figure 3 shows the frequency of the linkages between functionalities and urban problems. It shows that analysing and modelling was the most frequently mentioned functionality, which is furthermore highly related to transportation and mobility problems (59), followed by environmental problems (41), and to a lesser extent housing (34) and economic (34) problems. For the two other functionalities—namely informing and communicating and designing and visualization—the urban challenge of transportation and mobility is also the best connected to (34). All other combinations have much lower frequencies of the linkages. The dominance of transport and mobility reflects the huge impact it has on the urban environment (Benevolo et al., 2016).

The right-hand side of Figure 3 shows the average frequency of the linkages between functionalities and governance processes. All three types of functionalities are much more dedicated to supporting interactive processes than centralized processes. Among the linkages, the frequency between analysing and modelling and interactive process receives the highest score (45). Conversely, informing and communicating and designing are seldom applied to support centralized processes, respectively (17) and (15). The results confirm the finding that the identified technological functionalities focus more on supporting participatory forms of governance with non-state actors, than on supporting centralized processes (Vonk, 2006).

4.1.2 | Relation between frequency of the linkages and added value of functionalities

To find the relation between frequency of the linkages and added value created by functionalities, three subgroups (high, moderate, and low, based on their frequency of the linkages) of the 30 combinations were further identified for analysis. Figure 4 presents the possible relationship between frequency of the linkages and average added value score. It shows that the functionalities with high added value are mainly analysing and modelling and designing and

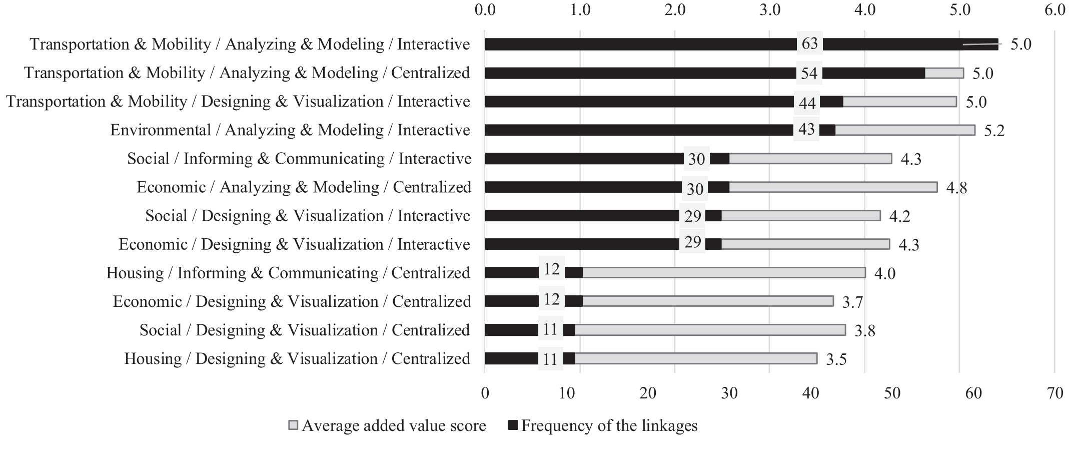

FIGURE 4 Possible relations between frequency of the linkages and average added value score

visualization, dedicated to supporting transportation and mobility and interactive processes, whereas functionalities with low added value are mainly informing and communicating and designing and visualization, dedicated to supporting problems related to people's daily lives (e.g., housing, social, and environmental problems) and supporting centralized processes.

To find dependence patterns in the variable concerning frequency of the linkages and average added value score, a regression analysis was made. Figure 5(a) shows that the higher the frequency of the linkages, the higher the added value scores of the functionalities. The average scores of different added value indicators were also analysed (Figure 5(b)). The figure shows that "learning about the object" scored 5.3, whereas "collaboration," "consensus," and "communication" scored only 3.4–4.1. A possible explanation is that the support capabilities of technologies are more focused on disentangling complex problems like analysing and modelling transportation and mobility problems, whereas the functional support to facilitate user's capabilities for participation, dialogue, and interpersonal communication is lacking in quality and/or regarded as much less complex. The results fit well with the high frequency of the linkages between analysing and modelling, urban problems, and governance processes, and the relatively low frequency of the linkages between informing and communicating, urban problems, and governance processes (i.e., the higher the frequency of the linkages, the higher the added value scores of the functionalities).

4.2 | ICT to smarten urban governance in subgroups

4.2.1 | Frequency of the linkages and its relation with the added value of functionalities

Subgroups of respondents were used for further analysis. Of the respondents, 58 were from NAEJA and 93 were from China. The analysis first shows that the patterns of the linkages between functionalities, urban problems, and governance processes in NAEJA and China are more or less similar to the pattern of the total group.

Regression analysis also confirmed the general result that the higher the frequency of the linkages, the higher the added value scores gained by the functionalities (Figure 6). However, it should be noted that the regression coefficient (0.0714) in NAEJA is greater than in China (0.0467), which indicates that the marginal effect of the frequency of the linkages on added value in NAEJA is larger than the effect in China. To identify the possible reason for this, the average scores of different contextual factors in NAEJA and China were compared (see Figure 7(a)). Figure 7 (a) shows that the effects of contextual factors on the role of functionalities in China are mostly bigger than they are in NAEJA, indicating that the role of functionalities in China is under greater constraint. This finding thus explains the difference in marginal effects of the frequency of the linkages on added value between NAEJA and China.

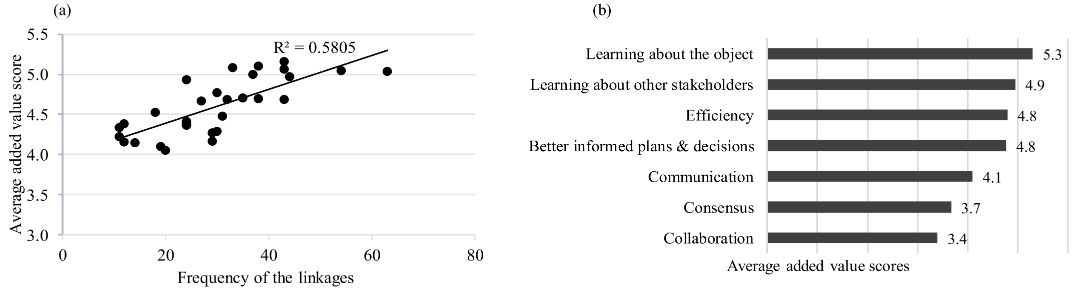

FIGURE 5 (a) Relations between frequency of the linkages and average added value score and (b) average scores of different kinds of added value

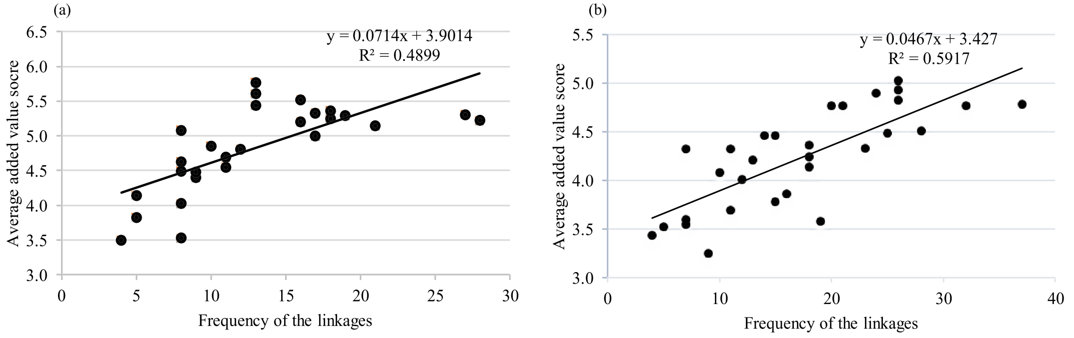

FIGURE 6 Relations between frequency of the linkages and average added value score (a) in NAEJA and (b) in China

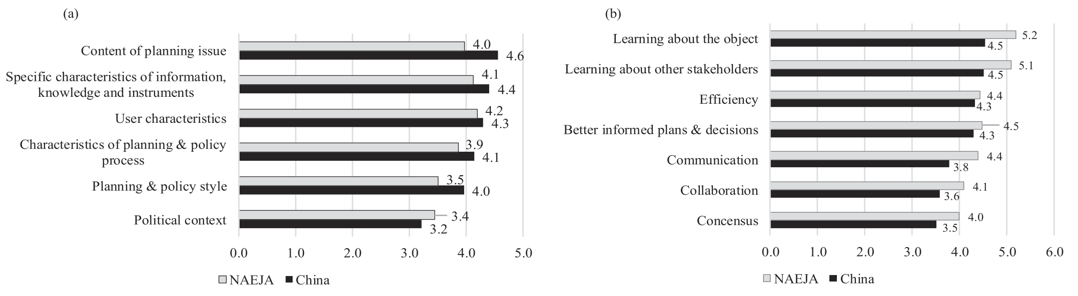

FIGURE 7 Average scores of contextual indicators (left) and average scores of different kinds of added value (right) in NAEJA and China

Figure 7(b) shows the average scores of added value indicators in NAEJA and China. The results accord with the finding obtained earlier for all respondents that high-quality analysing and modelling tools are more preferred, whereas there is a lack of functional support, or quality thereof, in facilitating user's capabilities for participation, dialogue, and interpersonal communication. However, comparing the scores of different kinds of added value in NAEJA with their China counterparts, reveals that the average scores of the seven added value indicators in NAEJA are slightly higher than the average scores in China. As shown earlier, the frequency of the linkages of different combinations of functionalities, urban problems, and governance processes in NAEJA is, on the whole, higher than in China. Thus, the higher scores of different added value indicators in NAEJA agreed with the general results; that is, that functionalities within higher linkage combinations result in higher added value scores, and vice versa. Besides, the different average scores of added value indicators also accord with the finding that the effects of contextual factors on the role of functionalities in China is stronger than in NAEJA.

5 | INTERPRETATION OF THE RESULTS

To better understand the results, the 12 expert interviews were further analysed to cross-validate the survey results. First, it is noteworthy that the dominance of analysing and modelling and transport and mobility was verified by the expert interviews. Of the 12 experts interviewed, 10 were involved in smart projects related to transportation and mobility problems. As one expert said, “Mobility problems are an important area for smart cities because of mobility's huge environmental, economic and social impact” (Expert 3). In addition, the majority of the technological functionalities in their smart projects were linked with analysing and modelling. For instance, some functionalities offer digital tools to provide an informative picture of spatial travel behaviour in Beijing, China; others are involved in the evaluation, assessment, design, and siting of cycling lanes in São Paulo, Brazil; and yet others are used to support the analysis and visualization of unaffordable properties in Sydney, Australia. One key reason for the widespread adoption of analysing and modelling tools is due to the opportunities provided by new big data and new ICTs. Experts highlighted, for instance, that "for the past ten years, big data has been evolving into a very important area … it provides new 'oil' for previous modelling or visualization tools, so the use of big data analytics in current smart city projects is prevailing" (Expert 6). Besides, "[universities] try to skill people up and they will know how to work with big data and open data … hence, they become aware of using modelling simulation and urban data analytics" (Expert 2). In addition to the rise of big data and data-related education, "a lot of companies try to improve algorithms, from carpooling to simulation capacity … [the algorithm] improves the capacity of computing technologies and enhances the performance of some complex behavioural models" (Expert 3). This indicates that the emerging big data and data-related digital technologies provide new momentum to the development and application of analysing and modelling tools in the smart era, not at least in the complex urban field of transportation and mobility.

Then, in terms of the weak combinations of functionality, urban problems, and governance processes (mainly designing and visualization is less used to support housing, social, and environmental problems in centralized processes), experts claimed that "in the last twenty years, it's always been the idea that you want to make a lot of plans more visible to the public [i.e., citizens] earlier on and get their input with respect to design and land use" (Expert 3). Almost all the experts stated that it is important to realize that smart urban governance is more about using ICTs to transform institutional conservation (centralized) into institutional transformation (interactive). Here, the perspectives of two Chinese experts are cited, since "one would not expect open governance in an authoritarian state" (Meijer, Lips, & Chen, 2019, p. 6): "From 2005 to 2015, urban planning in China entered a new stage, called the digital planning stage. The digital planning stage includes more networks, participation and communications to improve the efficiency and quality of plans" (Expert 7); and "the current technologies used in our project are mainly intended to the analysis and visualization of traffic flows and networks of cities, but the application of the outcome is restrained … we have therefore begun to focus more on digital enhancement design by engaging people who have interests" (Expert 9). Based on their views, the low frequency of the linkages can be understood from the perspective of a transformation going on in urban governance with more focus on participatory planning processes and a need for tools to support this active participation, including designing and visualization functionalities.

Second, the results reveal that functionalities in higher linkage combinations result in higher added value scores, and vice versa. This might indicate that to improve the added value of technological functionalities, more efforts focused on implementing technologies to solve urban problems and support governance processes are needed. However, the subgroup results show that contextual factors influence the role of functionalities. When we turn to the expert interviews, the relation between the frequency of the linkages and the added value produced by technological functionalities was vague; however, the expert interviews did confirm the strong effects of contextual factors. To better interpret the meaning of this finding, some distinct combinations of functionality, urban problems, and governance processes were selected (see Figure 8).

The four quadrants in Figure 8 represent the different patterns of the implementation of technological functionalities. The first and second quadrants indicate that the analysing and modelling functionality is relatively mature and stable in handling different urban problems and supporting both kinds of governance processes. Both quadrants indicate a high level of frequency of the linkages and added value. In that, "we should look at the success stories (successful or best practices) and try to learn from them" (Geertman, 2017, p. 75). However, compared with the first quadrant, the second quadrant indicates the underutilization of some analysing and modelling in specific areas (i.e., housing, social, and environmental problems), despite high support capabilities. As experts highlighted: "although some GIS, camera systems, and big data analytics are frequently used to deal with some urban problems and produce high value, the technical skills, knowledge, and unawareness of users could impede the use of technologies in urban planning" (Expert 2); besides, "the complex and wicked nature of urban problems makes it hard for computer-aided tools to work in reality" (Expert 8). This implies that implementing analysing and modelling tools to tackle housing,

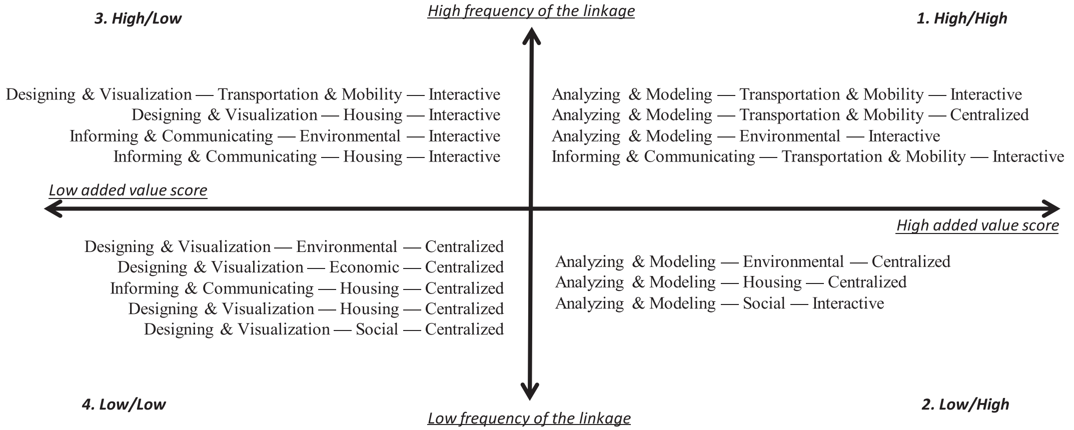

FIGURE 8 Some distinct combinations of functionality, urban problems, and governance processes, based on their frequencies of the linkages and average added value scores

social, and environmental problems should be more sensitive to the main bottlenecks (i.e., user characteristics, content of governance issues) to their usage (Pelzer, 2015). The third quadrant indicates that informing and communicating and designing and visualization are lacking in quality, although they are widely adopted. This can be perceived from one of the expert interviews: "ultimately while our tools were more accurate, more up to date, visually appealing, and fast … practice really needs software that everyone can understand and use" (Expert 10). This finding implies that technological innovations that can improve support functions of participation, interpersonal communication, visualization, and collective design should primarily be improved in quality (Klosterman, 1997). Finally, the fourth quadrant represents some technological functionalities (mainly designing and visualization) that are not much implemented in centralized governance processes (low added value scores). As experts highlighted, the recent wider context (e.g., the political environment of urban governance/planning) places more emphasis on incorporating smart functionalities to support interactive processes.

Finally, some methodological remarks are in place. First, it is not surprising that the most used combinations are also the most valued ones (because they are the most used). It is worth noting that this relationship was measured through a simplified reporting process, which means a range of other factors—such as user expertise level, characteristics of the urban issue, political attitude, and time pressure—were not considered as a part of the added value determinants. This could be part of a very nice follow-up research. Nevertheless, the present analysis helps to understand the possible mechanisms of transforming technological innovations into added value. Second, due to unavoidable limitations of the questionnaire design, we were unable to calculate the different kinds of added value referring to one particular combination of functionalities, governance processes and urban problems in one smart city project. Despite, the general overview helps us to understand the general performance of ICT in smart cities. Third, our respondents were mainly scholars and practitioners; no citizens were included in our analysis. However, since citizens' perceptions provide important insights into and much-needed knowledge on improving the supportive role of ICTs (Meijer & Thaens, 2018), it would be meaningful for further research to capture the perspectives of citizens who have participated in ICT-facilitated urban governance.

6 | CONCLUSION

The literature suggests that various smart ICTs and big data are being connected to urban governance to develop approaches that can make cities smarter. This paper presented a framework that provides guidelines on how ICT can produce added value to smarten urban governance. An international questionnaire and expert interviews were used to examine the practical application of technological functionalities in smartening urban governance and to measure the relevant added value produced by technological functionalities.

Based on the interpretation of the results, this paper revealed that: (i) The added value of ICT tools is best illustrated by analytical tools to tackle transportation and mobility problems, whereas some communicating and designing functionalities are less used; (ii) higher frequency of linkage between functionalities, urban problems, and governance processes results in the higher added value of these functionalities, and vice versa; and (iii) contextual factors have a significant influence on the process of transforming technological functionalities into added value. These findings lead to the following strategies to enhance the support capabilities of technological functionalities in smartening urban governance.

First, we could take a better look at the lessons learned from the more successful application of analysing and modelling tools, especially in the field of transportation and mobility, and see whether they are applicable to the less successful urban governance practices, namely housing, social, and environmental issues. Second, we should be more sensitive to the main bottlenecks (i.e., users' characteristics and the content of governance issues) to the widespread usage of some technological functionalities that have high support potentials (e.g., analysing and modelling and informing and communicating in tackling housing, social, and environmental problems). Third, technological innovations that can contribute to the creation of an enabling environment for citizen engagement and voluntary action require qualitative improvement. In particular, those informing, communicating, and designing tools should improve the quality of interpersonal communication, mutual learning, visualization, and collective design. Finally, although both the frequency of linkages and added value of functionalities in centralized governance are relatively low, this does not mean that there is no room for single entity, centralized innovations that are tailored to very specific needs (e.g., centralized highway management, city-wide traffic control system). We still need to contextualize the implementation of ICT in practice.

All in all, for improving governance processes and handling related urban problems, the results suggest that differentiated strategies should be employed. In this way, the use of ICT in smart planning can realize its full potential—and "smartening" urban governance can be achieved in specific contexts.

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Resumen. Este artículo presenta un marco conceptual que proporciona directrices sobre la forma en que la tecnología de la información y las comunicaciones (TIC) puede crear valor añadido para una gobernanza urbana inteligente. Además, el marco se aplicó para medir e interpretar el valor añadido de las funcionalidades de las TIC para la práctica de la gobernanza, a partir de un cuestionario distribuido internacionalmente (268 respuestas) y entrevistas a fondo con expertos (12 personas). Para mejorar los procesos de gobernanza y abordar los problemas urbanos relacionados, los resultados sugieren emplear estrategias diferenciadas. De este modo, el uso de las TIC en la planificación inteligente puede alcanzar todo su potencial y se puede lograr una gobernanza urbana "inteligente" en contextos específicos.

抄録: 本稿では、情報通信技術 (ICT)が、都市ガバナンスをスマート化するための付加価値をどのように作り出せるかということに関するガイドラインを提供するフレームワークを提案する。さらに、国際的な質問票(268の回答)と専門家の詳細な聞き取り調査(12名の専門家を対象)を基に、ICTの機能性のガバナンスの実行のための付加価値を測定及び解釈するためにこのフレームワークを適用した。ガバナンスの質を改善し、関連する都市問題に対処するためには、結果からは差別化された戦略をとるべきであることが示唆される。以上のように、スマートプランニングにおけるICTの活用では、ICTの可能性をフルに利用することができ、ある特定の背景において都市ガバナンスのスマート化を実現することができる。