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# How smart is smart? Theoretical and empirical considerations on implementing smart city objectives – a case study of Dutch railway station areas

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The current widespread attention on the concept of smart city in both policy and practice has stimulated academic discussion regarding the scope and applicability of this concept. An important question is whether cities and regions are truly advanced in implementing the concept in their policies and practices relative to its conceptual elaborations in academia. The aim of this paper is to analyse this congruence between theory and practice in the context of the ongoing transformations of railway station areas in European urban regions. Based on in-depth interviewing using aspects of Q-methodology, this paper investigates whether and how smart city concepts are implemented by stakeholders in three station redevelopment projects in the Netherlands. The results show that the current implementation of smart city concepts in practice is varied but modest and not (yet) very advanced. Knowledge exchange and innovations are currently hampered by a lack of acceptance and know-how among stakeholders, as well as by institutional and competitive constraints. For instance, stakeholders stress that data privacy regulations should be well organized before further implementation can occur. Transparency about how and what data are used may create more willingness among users to assist in developing and accepting new data technologies. However, the technologies are not yet completely developed, and concerns about the "loss" of personal privacy are holding back the widespread and advanced use of data supplied technologies. Although stakeholders seem to be aware of the opportunities the smart city concept offers, for now, the widespread implementation of innovative and advanced smart city concepts remains in the future.

**Keywords:** smart city; smart governance; railway station areas; Q-methodology; stakeholders

## Introduction

In recent years, the concept of the "smart city" has been taken up by many city leaders, IT companies and scholars worldwide, resulting in a flurry of professional (e.g., ARUP 2010; Washburn and Sindhu 2010), popular (Greenfield 2013; Townsend 2013) and scholarly (Deakin 2011; Glasmeier and Christopherson 2015) publications on the topic. To an increasing extent, both practitioners and policy-makers proclaim that their cities and regions are "smart", a designation exemplified by, for example, smart city events and rankings of smart cities. For example, Utrecht is one of the most competitive European regions and develops many smart projects related to climate policy, traffic, services, life sciences

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and gaming (The New Economy 2014). Amsterdam has its own smart city portal on which it promotes initiatives such as a 3D-printed canal house and a self-reliant sustainable energy network for the entire city. Such examples raise the expectation that these cities and regions are rather advanced in implementing the smart city concept in their policies and practices. The question remains, however, as to whether this is truly the case and whether conceptual elaborations from academia can indeed be empirically validated by the current – and supposedly advanced – state of implementing the smart city concept in practice.

The aim of this paper is to analyse the congruence between the use of the smart city concept in theory and practice. We use a scientific viewpoint to examine empirical uses of the smart city concept in the context of the ongoing transformations of railway station areas. These areas are under increasing spatial pressure and are in need of quality improvement to meet the changing needs and demands regarding the node and place value of contemporary transportation hubs (Bertolini, Curtis, and Renne 2012). Consequently, the ambitions and characteristics of the smart city concept can be connected to the desire to improve the quality of railway station areas. Of course, the redevelopment of such areas is by no means a new phenomenon in Europe; railway station renewal projects have been high on the European policy agendas for decades (e.g., Bertolini and Spit 1998). Over time, however, attention has shifted from a focus on the development of multimodal nodes towards an increased awareness of the importance of the urban context in the (re)development of the railway station area (e.g., Zemp et al. 2011). Railway stations will still have an important transit function, but their integration with the surrounding urban context is gaining more prominence. Particularly in the densely populated urban regions of Europe, where vacant space is scarce, redeveloping railway stations is inevitably intertwined with surrounding urban land uses and will exacerbate conflicting interests.

This changing focus in railway station area redevelopment bears similarities to certain characteristics of the smart city concept. Many Dutch cities are currently experimenting with “smart” applications in the redevelopment of their railway station areas. For instance, Utrecht is working on a digital parking system for cyclists, Amsterdam has an electronic time table system for regional public bus transport which is integrated with other transport modes and Rotterdam is generating sustainable energy by means of solar panels on the roof of the renewed railway station building. Given these examples, it is interesting to examine what constitutes a “smart” railway station area and what exactly constitutes “smart” in the eyes of the stakeholders involved. This paper reports on empirical findings from three large-scale railway station area redevelopment projects in the Netherlands (Amsterdam, Rotterdam and Utrecht), in which it is investigated whether and how the characteristics of the smart city concept are used and what this implies for the stakeholders that facilitate the redevelopment of the these areas.

The remainder of the paper is structured as follows. The next section presents a brief theoretical overview of the smart city literature, in which four major components of the smart city concept are distinguished. These components are used in the in-depth interviews with stakeholders in the Dutch railway station areas of Amsterdam, Rotterdam and Utrecht. The case study areas and their stakeholders, as well as an elaboration on the method used, based on aspects of Q-methodology, are discussed in section “Research methodology”. Section “The smart city in practice: evidence from three Dutch railway station areas” reflects on the most important findings. Finally, the outcomes are related to the current scientific and policy debates on governing the smart city.

## The smart city concept: from data input to knowledge exchange and innovation

Screening the literature turned out that at the moment a uniform definition of the concept of "smart city" is lacking. There is no general consensus on its definition at the moment (e.g., see Hollands 2008; Lombardi et al. 2012). Therefore we performed an extensive literature review to find out what would be a good definition of the "smart city" concept. From that it turned out that most authors include the technology component. They consider innovations in technology to be at the core of the smart city concept. Furthermore, some add to that the historical link to the American sustainability concept "Smart Growth". This is foremost taken up in a broad sense, so including ecological, economic and also social sustainability. Furthermore, in literature several other components have been proposed, which can be summarized foremost on the one hand with the term "social capital", and on the other hand by the term "governance". We will elaborate on these concepts in the foregoing. Based on the identification of these four components we found a congruent broad definition of the "smart city" concept: " … when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu, Del Bo, and Nijkamp 2011, 70). A definition which is very much in accordance with the thoughts expressed by several other authors (e.g., see Kourtit et al. 2015; Lombardi et al. 2012; Lombardi and Vanolo 2015).

The mentioned four components of the smart city concept are briefly discussed below.

### *Technology*

First, for many authors, the concept of the smart city finds its origin in debates about how Information and Communication Technology (ICT) can contribute to the planning and management of cities (e.g., Papa, Gargiulo, and Galderisi 2013). In this way, a smart city or equivalent terms like "wired", "digital" or "intelligent" city refers to an urban environment where "pervasive" or "ubiquitous" computing has introduced a range of digital devices for sensing, monitoring and managing the city (Kitchin 2014; Komninos 2002; Papa, Gargiulo, and Galderisi 2013). After Batty et al. (2012, 19), in general, this associated ICT support can be summarized as

> … first, portals and other access points to [add] useful information about any aspect of routine living and working in cities, second, ways in which citizens can interact with software that enables them to learn more about the city by engaging with other users online and actually creatively manipulating information, third, citizens engaging with crowd-sourced systems in which they are responding to queries and uploading information, and fourth, fully fledged decision-support systems which enable citizens to engage in actual design and planning itself in terms of the future city.

This ICT infrastructure – referred to as the digital/intelligent/virtual/hybrid/ubiquitous/information city – is needed to collect and manage new sources of data, conduct analyses and ultimately use connected devices to manage cities in new ways. Four interacting layers can be identified and ordered, from the bottom up, as the sensor layer, network layer, platform layer and application layer (Figure 1). Data, possibly the so-called big data, are an outcome of this infrastructure, which asks for new data analytical tools and instruments to transform these data into usable information (Batty et al. 2012). One can imagine that so-called Planning Support Systems (PSS) – for instance, in the format of "city dashboards" – can include these types of ICT characteristics and, in that way, can be used as

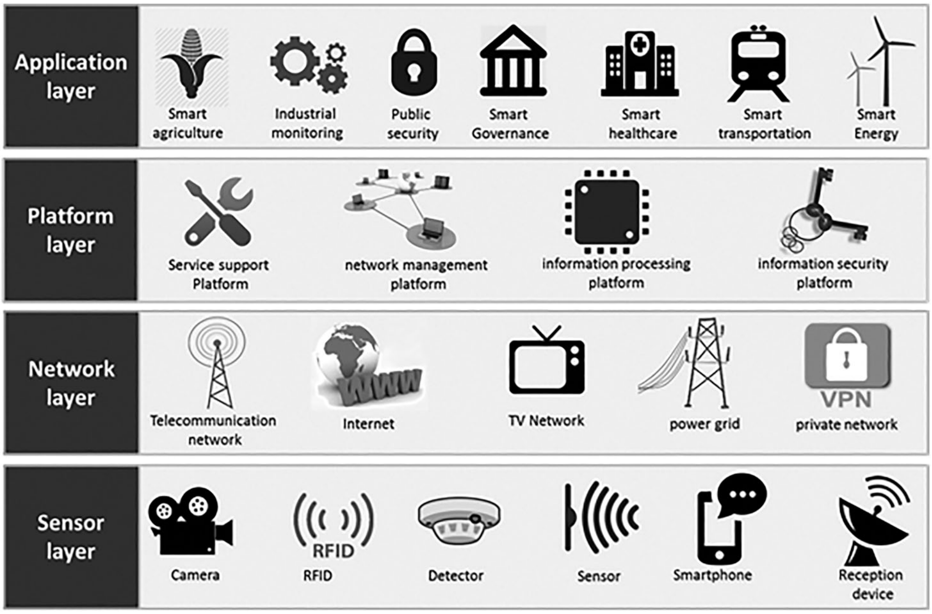


Figure 1. The four layers of a smart ICT infrastructure Yongling Li (2016).

"smart" systems that can play a crucial role in the management of the smart city (e.g., Geertman et al. 2015).

### *Sustainability*

Other groups of authors have stressed the sustainability component of the smart city concept, particularly its origins in the "smart growth" planning concept (Burchell, Listokin, and Galley 2000; Daniels 2001; Harrison and Donnelly 2011). This sustainability-related concept, which arose as a reaction to the excessively automobile-oriented urban sprawl around many US cities, promotes the adoption of a diversity of urban growth management policies. As Cervero (2002, 1) puts it, "Stripped to its essentials, smart growth is mainly about better coordinating and integrating transportation and land development." In this way, one can think of policies for urban growth boundaries, rural land preservation and financial incentives to discourage growth at the urban periphery. For instance, smart growth advocates a more efficient use of land in urban regions, reduced car use and commuting distances, more mixed land uses, reduced water and energy consumption, greater efficiency in infrastructure systems, improved quality of life, improved variety of housing types and greater housing affordability (Alexander and Tomalty 2002). In short, smart growth promotes a range of ecological, social and economic benefits.

In defining this sustainability component of the smart city concept, we understand sustainability as it is referred to in the Brundtland report (1987). Related to governance, this definition implies that active intervention in space and society is not just aimed at short-term benefits but has an explicit future-oriented dimension. Thus, potential intervention should also incorporate the possible implications of present-day choices for future generations. Furthermore, as the concept developed, it has shifted from purely environmental protection to the interplay of economic prosperity, social equity and environmental protection (e.g., see Campbell 2013). At the moment in general the sustainability concept refers to the proper trade-off among its three dimensions of environmental, economic and social sustainability. However, despite its relatively long history, the concept still is badly defined and elaborated upon. Moreover, at present attention is focused foremost on the ecological/environmental component, leaving the other two to lag quite far behind, likewise the interplay of the three components (e.g., Goedman and Zonneveld 2007; UCAD 2009).

### *Human and social capital*

Another group of authors stresses knowledge exchange and innovation – the inclusion of human and social capital –as a crucial component of the smart city concept (e.g., Papa, Gargiulo, and Galderisi 2013). These theorists stress that the logo of a smart city is not just in the introduction of ICT technologies or in striving to achieve sustainability goals; in their opinion, the promotion and inclusion of human and social capital is also a key part of the smart city concept (Neirotti et al. 2014). Along this line, Hollands (2008) notes that the embedding of ICT in urban infrastructure is not sufficient to make a city smart. According to him and others (e.g., Kourtit, Nijkamp, and Arribas 2012), the term "smart city" refers more broadly to the development of a knowledge economy within a city-region. In the same line of reasoning, Nam and Pardo (2011) recognize creativity as a key driver of smart cities and thus consider people, education, learning, and knowledge to be of central importance to the concept of a smart city. Furthermore, they encounter a smart city as a centre of higher education and a smart workforce. According to them, the problems associated with urban agglomerations can be solved mainly by means of creativity, human capital, cooperation among relevant stakeholders, and their innovative scientific ideas, or in a nutshell, by generating "smart solutions" as an outcome of the input of human and social capital. This all is in accordance with the so-called "triple helix" model. This model has emerged as a reference framework for the analysis of knowledge-based innovation systems, and charts the multiple and reciprocal relationships between main agencies in the process of knowledge creation and capitalization like universities, industries and governments (Kourtit et al. 2015; Lombardi et al. 2012). In fact, it can be argued that cities can become "smart" when underlying investments by universities, industries and governmental organizations support the development of communication infrastructures and this in turn fuels sustainable economic growth and a high quality of life (Kourtit et al. 2015). In the next paragraph we will elaborate more on the interplay of these diverse actors in the framework of smart governance.

### *Governance*

In addition to the above three components, the concept of the smart city includes institutional preparation and community governance as essential factors in the success of smart community initiatives. Alternately, as stated by Nam and Pardo (2011, 287), "The support of government and policy for governance is fundamental to the design and implementation of smart city initiatives." Giffinger et al. (2007) also include governance in their conception of the smart city. Therein, smart governance entails participation in decision-making processes, the transparency of governance systems, the availability of public services and the quality of political strategies. More generally, governance can be encountered as the process of interaction and decision-making among the stakeholders involved in a collective issue (Hufty 2011). Smart governance then involves the organizational and institutional embedding of ICT into urban governance (Komninos 2009). On the one hand, big data, data warehousing and monitoring tools can be used to strengthen the information base of the government (Batty et al. 2012; Leydesdorff and Deakin 2011). On the other hand, social media and the Internet can be used to enable the collaboration of various actors at different stages of governance processes (Hoon, Phaal, and Lee 2013).

Chourabi et al. (2012) summarize a range of characteristics of smart governance, including effective collaboration, leadership, public participation, transparency in decision-making, public–private partnerships, efficient communication, data exchange, and service and application integration. According to Nam and Pardo (2011), these smart governance components can be envisioned as essential characteristics of successful smart cities. In terms of actors in smart city governance there is a growing role for citizens (civil society) in addition to three other types of actors, defined in a "triple helix" model (Kourtit et al. 2015). It is argued that collaboration between these actors strongly influences the smartness of a city (Lombardi et al. 2012, 139). Because smart governance focuses on enabling, with the help of ICT, the participation and collaboration of various actors, such as described before, in the decision-making process and supporting transparency in governance, it has an obvious connection with so-called collaborative planning (see Healey 1997), which occurs among different functional sectors and parties (e.g., government, business, academics, non-profit and voluntary organization) and among different jurisdictions within a given geographical region. Thus, the sharing of concepts, visions, goals, priorities with the public and with diverse public and private stakeholders is of prime importance in the achievement of smart governance.

### *Towards a smart city definition*

Taking these sources, backgrounds and components together, several authors have proposed a definition of a smart city that unites both ICT-based support and sustainability goals into one overarching concept in which the knowledge component and governance plays a central role. As stated by Nam and Pardo (2011, 288),

> Technological innovation is a means to smart city, not an end. IT is just a facilitator for creating a new type of innovative environment, which requires the comprehensive and balanced development of creative skills, innovation-oriented institutions, broadband networks, and virtual collaborative spaces.

In line with this broader perspective, Caragliu, Del Bo, and Nijkamp (2011, 70) define the concept of the smart city as " … when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance". In this definition, the four previously distinguished components of the smart city concept are included explicitly. Several other authors on smart city adhere to this definition of the concept too (e.g., see Kourtit et al. 2015). In this paper, we conform to this broader perspective on the smart city concept, in which the following four major components interact to fulfil a crucial role: (1) technology, (2) sustainability, (3) human and social capital, and (4) governance.

## Research methodology

As noted above, the goal of this paper is to analyse from a scientific viewpoint the empirical uses of smart city concepts. This paper provides more insight into the ways in which smart city characteristics, as described in the literature, fit into the redevelopment of railway station areas. It is important to find this congruence or incongruence between theory and practice because there appears to be a sharp distinction between the smart city in the scientific literature and the smart city in practice. This research explores how these two concepts relate to or differ from each other using three case studies. This paper conducts an explorative analysis of the broader context of a “smart” railway station area on basis of 12 semi-structured, in-depth interviews with stakeholders and external consultants.

### *Selection of case study areas and stakeholders*

We selected three case studies of new railway station area redevelopment projects in the Netherlands. Because the smart city concept has only recently become an important urban concept, it is more likely that “smart technologies” are mainly used in current or future renovations. In Amsterdam, many “smart city” initiatives are inter alia assembling under the heading “Amsterdam Smart City”. The city’s central station is currently being renovated and therefore presents an interesting location for the combination of the smart city concept and the redevelopment project. The same goes for Utrecht, where the railway station renovation is underway and digital technologies are already being applied. The central station in Rotterdam is the only one of the three cases that has already been completely redeveloped recently. The city itself has been labelled a “smart city” (The New Economy 2014), which makes it interesting to investigate whether this label influenced the renovation (because the plans for the redevelopment were developed before the rise of the smart city concept in public policy). As mentioned above, these three cities prioritize the concept of the smart city.

Following the definitions of smart governance presented above, this research focuses on the stakeholders who have responsibilities in the *redevelopment* of the railway station areas. The participants in this research (see the Appendix for a full overview) are the municipalities of the three case study areas (Amsterdam, Rotterdam and Utrecht), three regional governments (the city regions of Amsterdam, Rotterdam and Utrecht), transport operators (U-OV; NS Dutch Railways; ProRail). Municipalities have spatial policies for the railway station area and are often co- or main-clients and co-financiers for their redevelopment. Regional governments are responsible for the organization of public transport, its infrastructure and the commissioning of transport operators in the region. Transport operators are partly responsible for public transport in the Netherlands. In addition, NS Dutch Railways has commercial facilities and real estate development in its portfolio. ProRail manages the railway network in the Netherlands.

### *In-depth interviewing and Q-methodology*

With the help of a topic list based on the literature review, participants were asked about the redevelopment of the railway station areas, which drew attention to specific characteristics of the smart city concept that are possibly being implemented in this redevelopment process. We used member validation to increase the reliability of the research by summarizing the interviews and asking the participants for feedback. To supplement the in-depth interviews with stakeholders, additional interviews with external consultants were conducted with representatives of Dutch research and consultancy firms.

The discussions with participants were further supported by using Q-methodology. In this method, participants are asked to rank certain statements in a ranking system by assigning value to a statement (cf. Uittenbroek et al. 2014). In this case, characteristics of the smart city concept that were extracted from the scientific literature were transformed into statements and ranked. The participants ranked those statements – according to their perceived importance – from least to most important for the redevelopment of a railway station. Participants were specifically asked to make their rankings while keeping in mind their corporation/business and not to rank from an individual point of view. From the discussions that started during the process of ranking the statements, the participants' feelings and choices regarding the use and implementation of smart themes in the redevelopment could be derived. The Q-methodology was useful for this case because the smart city has many different characteristics that can be interpreted in many different ways.

The method used here deviated from the regular form of Q-methodology in three ways. First, the Q-set – a set with all the statements that must be ranked – included two empty cards. Participants were able to fill in these empty cards themselves. This decision was made because, as discussed above, the smart city concept is a fuzzy concept with many different interpretations. Participants had the ability to name and write down their own important themes of a smart city, which were then ranked in the same scheme along with the themes derived from the literature. Second, the type of statements differed from each other. Some statements were goals, whereas others were resources. Third, the method of analysis differs from a regular Q-methodology analysis. This empirical research used a qualitative manual analysis instead of a quantitative factor analysis, which is normally used in the Q-methodology (Uittenbroek et al. 2014). A manual analysis was chosen because the group of participants was relatively small and the insertion of two "empty" cards made a software analysis unnecessarily difficult. The limited number of Q-sorts ensured that a manual analysis of the results provided an organized overview of the results.

## The smart city in practice: evidence from three Dutch railway station areas

This section describes the most important results of the in-depth interviews with stakeholders in the Dutch railway station areas in Amsterdam, Rotterdam and Utrecht based on the four components identified in the literature review. Thereof, it should be identified that there is never a direct match or one-to-one relationship between "theory" and "practice". In "theory" one seeks for generally valid statements that abstract from all the peculiarities of particular cases. Its value can be found in its general applicability, which offers the possibility to frame particular cases in a broader sense. In contrast, in "practice" one seeks for the specific peculiarities belonging to that specific case. In this, precisely these peculiarities of the specific case make it worthwhile to investigate, because these also offer the possibility to compare with other cases. As a consequence, it is not so useful to try to identify the direct differences and possibly commonalities between "theory" and "practice". Instead, in the confrontation of "theory" and "practice" we are looking for the presence or absence of the translation of "theory" into "practice" and question ourselves how and especially in what sense this translation has taken effect. This is done with the help of the acquired overview of participants' perceptions of a broad range of smart city characteristics in the context of Dutch railway station areas.

### *Technology*

As noted above, ICT can contribute to the planning of cities, and in this specific case, the planning and management of railway station areas. The findings of the empirical research reflect that in all three cases (Rotterdam, Utrecht and Amsterdam), data and ICT are playing an explicit role, though it is not (yet) always in an advanced way. The Utrecht participants and transport operators in particular rank “data” as an important means of making the railway station area smarter. The use of various types of data and ICT can be related to Figure 1, which explains in which layers data and technology can be categorized.

In the *sensor layer*, data like GPS data, sensor data or mobile phone data are being collected and monitored. The regional government and transport operator in Utrecht, for instance, cited the existence and usage of “on-board computers” that detect when a bus or tram arrives at certain stops and when they continue their routes. In the interviews, however, all participants indicated that there are more possibilities for data and ICT than are currently in use. Here, one can think of, for example, providing online accurate information on delays or the crowdedness of buses and trains during rush hour. Moreover, it has been indicated that the application of data and ICT for the purposes of predicting, restoring and/or preventing certain unwanted situations is not yet common, although many technologies are already available. In fact, these findings bear resemblance to insights from the debate on PSS regarding the implementation gap between the supply and demand of such tools (e.g., Geertman 2006; Pelzer 2015; Te Brömmelstroet and Bertolini 2008).

In all three cases, the limited use of data and technology suggests that data are often “stuck” in the process of implementation and thus never reach the application layer. To avoid this, the regional government of Amsterdam and the transport operators state that it is important to ensure first that the data processing is well organized before stakeholders use the data in their policy or technologies. This can be related to the *network layer* because investments in the supporting infrastructure play an important role in this stage of data processing (Figure 1). Different participants stated that there was insufficient commitment to invest in a network to support more advanced ways of using data. In addition, privacy issues play a major role in the limited data acquisition and more advanced application of data.

Related to the *platform layer*, the topic of the digital security of data was often addressed in the empirical research. Digital security defines itself as securing the privacy of people whose data (e.g., mobile phone or GPS data) are being used for applications in the railway station areas. The transport operators, the external consultants and even some of the governmental participants note that their main concern about incorporating collected data into real applications relates to privacy issues, which are visible in Figure 1 as the “information security platform”. Several participants note that users’ privacy must always be guaranteed but that the trade-offs between the better provision of information and maintaining privacy are difficult. A transport operator also stated that users who need or want specific travel information – for example, a disabled person may want to receive specific information on personal assistance such as specific guidance through less-crowded routes – may settle for less data security in exchange for better and more personalized information. Moreover, the external consultants indicate that the use of personal data will become more “normal” and accepted in the future, when it is expected that people’s fear of “losing” some of their privacy will decrease.

The accessibility and usability of “open data platforms” in the context of railway station areas was also addressed in the interviews. This can be envisioned as part of the “service support platforms” in Figure 1. Our empirical research showed that the creation of an open data platform with public data is a high-priority topic for the municipality and regional government of Utrecht and for the transport operators. The data on these platforms will consist of route and travel data for public transport operators, information on congestion and delays, and so on. An open data platform can either be a platform where stakeholders share their data mutually or a platform on which all data are available to anyone (e.g., users and consultancies as well). The last form is most stressed by the external consultants, transport operators and governmental actors. Organizations can use each other's data and information to create new technologies or provide better information to users. In addition, external actors, similar to consultancies, can use the open data for applications or technologies, which they can present to the stakeholders. In fact, the empirical results show that the governmental actors in Utrecht are already busy with creating an open data platform.

However, a real, all-embracing open data platform does not currently exist because of its encountered complexity and the absence of procedural guidelines for its production. Furthermore, in several of the interviews, it was expressed that some actors, such as the transport operators, could be afraid of losing their competitive advantages if all information were openly available on such an open data platform. It is possible that a "trusted third party" could mediate this. In fact, these findings are in line with the institutional and competitive constraints in the context of the efficiency of intermodal transport in Europe as mentioned by Witte et al. (2012). It could thus take some time for a real open data platform to arise, but this research shows that different stakeholders are interested in setting up or joining in such a data platform. The expected advantages of such a platform would be that it would make all data acquisition uniform and the data easy to exchange among different stakeholders.

With regard to the *application layer*, railway station areas offer many different applications to their users. Digital information about a journey is the most used and best known example. This information appears on websites (e.g., www.9292ov.nl), apps (9292ov,[1] NS Dutch Railways app) and digital panels in various places in the railway station area. This informs users about their journey (e.g., delays, changes of platform and switching transport modes). Transport operators are able to update the timetable according to real-time data to ensure that the timetable corresponds as closely as possible to the real-time departure times. This helps passengers to be flexible in their travel routes and modal choice. In the research, "wayfinding" also came up as one example of using technology to improve service to travellers. Wayfinding helps users guide themselves through a railway station area. This project could be in the form of an application that guides travellers to their platform and lets them know whether they must hurry. With this technology, railway station areas can improve their service to users and ensure that the journey is as obstacle-free as possible. The interviews in Utrecht and Amsterdam also showed that digital infrastructure is now being used or will be used to improve car and bicycle parking facilities in the railway station areas by making them more efficient with sensors that detect if a spot is occupied, by providing information on opening times and occupation rates and by directing users to the correct (and available) parking spots.

Although much of the literature on the smart city concept focuses on the use of data and ICT and although data were perceived as important in most of the interviews (especially in Utrecht and Amsterdam and for the transport operators), the support for and awareness of the importance of data and technology are not widespread, and data are currently not being used in an advanced way. It seems that although many data are available, these data do not always reach the stage of the application layer. Some technologies are not yet fully developed, and in particular, concerns about the "loss" of personal privacy are holding back a more widespread advanced use of data supplied technologies in Dutch railway station areas.

### *Sustainability*

In the empirical research, all three aspects of the sustainability concept were observed, though in varying degrees of importance. One of the topics related to *environmental* *sustainability* that received significant attention was the influence of biking in cities. By promoting biking, railway station areas can become more ecologically friendly, and bicycles need less space than do other modes of transport (e.g., cars). Given the present-day widespread utilization of "sustainable development" as a desired goal in policy-making, however, it was remarkable that the environmental sustainability component of the smart city concept was often perceived as less important than other smart city characteristics such as data application or economic sustainability. Nevertheless, regional governments and transport operators (Figure 2) in particular state that environmental sustainability is certainly important, as expressed, for instance, in the application of solar panels.

Another oft-expressed smart aspect is the wish to create optimal capacity in railway stations. Dutch railway stations have had problems with capacity because of the tremendous growth in users of public transport and their changing demands and wishes. Railway station areas were badly in need of expansion to be able to manage the growing number of users while still fulfilling the desires of travellers for more shops, restaurants and coffee places. However, railway stations are generally located in the Dutch inner cities with limited space, so the existing infrastructure must be used optimally. The empirical research shows that to address these conflicting demands, the redeveloped railway stations all seek to become more dynamic in their capacity.

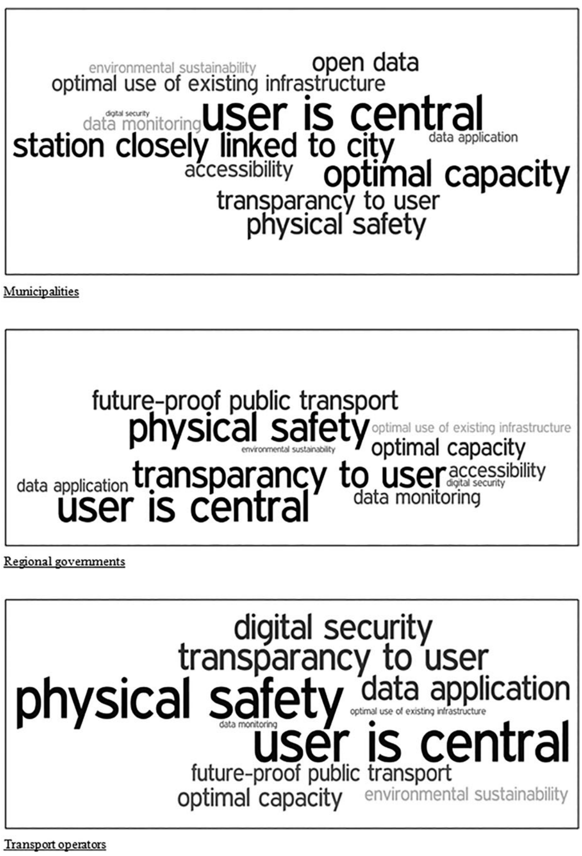


Figure 2. Schematic overview of stakeholders' perceptions of smart city characteristics.

In this sense, *economic sustainability* can be related to technology. With the use of big data, information on flows of travellers can be monitored, for instance, to prevent capacity problems. By advising users to take the public transport from another railway station or at another moment in time, capacity problems, even in times of growing demand for public transport, can be reduced. Experiments will begin to use hub-stations in a more dynamic way by using them more selectively for transfers while spoke-stations are used to a larger extent as terminal stations. Other experiments include the dispersion of users based on the time of day or better guidance of users by means of signs and signals (with the use of technology). All of the case study areas have specific tactics to make their railway station areas more future-proof and innovative by combining technology with the increase of capacity (e.g., through apps that inform passengers with real-time travel alternatives, such as travelling via a spoke-station instead of a hub-station). The empirical research shows that economic sustainability is important in terms of capacity.

In terms of *social sustainability*, the issues of safety, both physical and digital, and the accessibility of public transport were named by all participants as important aspects. Physical safety, both in "normal" situations and especially in times of station redevelopment, is always high on the agenda for everyone. For the municipality of Utrecht, creating greater physical safety even serves a broader purpose than "just" physical safety as such: "Physical safety is to bring the whole physical environment to a higher quality [authors' own translation]." In terms of social safety, one of the external consultants cited the presence of camera surveillance and lighting use in railway station areas. Smart lighting systems also increase the feeling of safety in less-crowded places in the railway station or at night.[2] In Utrecht, a "city dashboard" was developed in 2013 (called "Safety Monitoring System") for the continuous, real-time monitoring and analysis of safety aspects in the city-region of Utrecht. NS Dutch Railways also makes use of such real-time monitoring software in operating their railway station areas.

Accessibility is related to physical accessibility for travellers but is also closely related to the technology aspect of the smart city. It was indicated that even people who are not accustomed to digital technology in the form of apps and websites should be able to receive good service in the railway station area. One of the external consultants working with smart concepts stated: "There are some groups of people, I am talking about elderly people, who can hardly survive such digitalized railway station areas without proper knowledge of the software (digital panels, apps, electronic public transport tickets, etc.) [authors' own translation]." Thus, the smart city is not only about innovation in the form of technology but also about increasing social sustainability by creating enhanced accessibility for every traveller. Additionally, the concept of social sustainability relates to the privacy aspect of data described in the previous section. As stated above, a transport operator mentioned that some people may be more willing to give up some of their privacy to increase their accessibility.

Although all three types of sustainability described in the literature review above seem to be equally important for the smart city, the empirical research reveals a different story with a more varied picture. Ecological sustainability seems to wane in importance compared with economical sustainability and, to a lesser extent, with social sustainability. At the same time, it seems to have become "common practice", and many sustainability initiatives have been implemented (visible, for instance, in the widespread use of solar panels). For many stakeholders, the ability of railway station areas to become "future-proof" and be able to handle the growing demand for public transport is more important than the ecological resilience of railway station areas.

### *Human and social capital*

A third component of the smart city concept is the growing importance of human and social capital, which is associated with knowledge exchange and innovation. The desire for innovation has been seen in the use of data and ICT, although the interviews show that innovation in data and ICT has not yet been accomplished. However, innovation and the desire to exchange knowledge can be found in another aspect that comes with "smart": human and social capital. For instance, railway station areas seen as "hubs" for knowledge exchange in the city as nodes for people to come together and share their knowledge. This occurs in all three cases because they all have offices, conference rooms and other places for people to come together and exchange knowledge. The "*Groot Handelsgebouw*" [Wholesale Building] in Rotterdam and "*Hoog Catharijne*" [indoor multifunctional shopping mall] in Utrecht are examples of conference centres; "Seats2meet" is an example of a flexible business location for knowledge exchange that has locations in Utrecht's railway station area. In all three cases, many head offices of commercial service providers (e.g., banks, insurance companies) are concentrated around railway stations, despite the high land prices in those areas. In one of the interviews with external consultants, it was stated that railway station areas are increasingly becoming intertwined with the rest of the city and that broader mix of functions seems to be becoming more common.

In contrast, one could argue that in some cases, policy unintentionally downplays the importance of human and social capital. For instance, in one of the interviews with transport operators, it was noted that some railway stations have "barricaded" the entrances in the form of automatic gates that can only be opened using a valid public transport ticket. These gates can thus exclude non-travellers from the railway station area and most of its facilities. The railway station is closed for safety concerns but highlights a paradox between creating a mixed-use location that "flows" into the rest of the city to facilitate exchange in human and social capital and keeping the railway station area a "club member area", that is, an area that is only accessible to travellers with a valid public transport ticket. This contradiction clearly indicates that what is smart for some stakeholders is not smart for others. There is a governance aspect here that is explored in depth in the following section.

### *Governance*

The final component of the smart city concept relates to the governance "motivations" that are behind all of the smart city characteristics described above. Railway station areas are especially interesting in terms of smart governance because they are by definition areas in the city where different stakeholders (physically) come together. The railway station area was referred to as a "melting pot" of interests, desires and responsibilities. In the three case studies, local and regional governments in addition to transport operators and knowledge institutions are important actors. The results of the Q-methodology exercise also clearly highlight these diverging interests between different groups of stakeholders (Figure 2).

In a general sense, it can be stated that although there is alignment on the importance of some aspects, different actors, to a great extent, possess different views of what is considered important in the railway station areas. As seen in Figure 2, all actors view the central position of "the user" in the redevelopment of the railway station areas as the most important "smart" characteristic. This can be understood and, to a certain extent, can be expected as part of imaging strategies and creating "goodwill"; at the same time, it is remarkable that not all actors consider "environmental sustainability", which is another "popular" issue for imaging in policy strategies, to be particularly important. Important differences between the groups of stakeholders seem to relate to the scale and scope of the redevelopment projects. Whereas the municipalities are mainly concerned with the capacity of the railway station area and connections with the city, the regional governments and transport operators take a more strategic interest in making public transport future-proof. Another difference is the importance of physical safety for the transport operators, whereas this aspect is only of moderate importance for the municipalities. Finally, regional governments often hold an intermediate position between the diverging opinions of the municipalities on the one hand and the transport operators on the other.

The varieties in rankings of the smart city characteristics can be ascribed either to different circumstances in the three cities or to the distinctive positions of the different actors. The transport operators, for example, want to deploy data for innovation in public transport. This relates to the search for knowledge exchange and innovation, which is also seen in recent literature on the smart city concept. The municipalities have other priorities in their policies on their cities in general and on their railway station areas in particular. Municipalities, for example, focus on diverting cars from the inner city to make it safer and more pedestrian- and cyclist-friendly and to offer more space to public transport (bus, metro and tram). This can be related to the smart growth movement (i.e., transit-oriented development), as mentioned in the literature review. In addition, these local governments try to present their entire city as being accessible, in which railway station areas can be an important factor. The various responsibilities of actors are complex and suggest that these parties have different priorities in managing smart city objectives in their daily practice.

## Conclusion and discussion

The aim of this paper was to analyse the congruence between the use of the smart city concept in theory and practice. Or as stated more precisely before, in the confrontation of "theory" and "practice" we have looked for the presence or absence of the translation of "theory" into "practice" and question ourselves how and especially in what sense this translation has taken effect. Taking the various sources and concepts in the academic literature on the smart city together, this paper has conformed with a broader perspective on the smart city that unites technology, sustainability, human and social capital and governance in one overarching understanding of the smart city concept. Using in-depth interviewing and aspects of Q-methodology, the paper has investigated whether and how "smart" characteristics are used by stakeholders in three large-scale railway station area redevelopment projects in the Netherlands. The results show that the current implementation of the smart city concept in practice is varied but primarily modest and, as such, is not (yet) very advanced. At least four important conclusions related to the four smart city components in the literature come to the fore.

First, with regard to technology, although much of the literature on the smart city concept focuses on the use of data and ICT and although many of the participants perceive data as important, the support for and awareness of the importance of data and technology are not widespread, and data are currently not applied in an advanced way. It seems that although a great deal of data are available, these data do not always reach the application stage. Some technologies are not yet fully developed, and concerns about the "loss" of personal privacy are holding back a more widespread and advanced application of data and technologies in Dutch railway station areas.

Second, related to sustainability, although all three types of sustainability seem to be of importance in the smart city concept, according to the literature, the empirical research reveals different findings. Ecological sustainability seems to lose importance compared with economical sustainability and, to a lesser extent, with social sustainability. At the same time, it seems to have become "common practice", and many sustainability initiatives have been implemented (visible, e.g., in the widespread use of solar panels). In the eyes of the governmental actors and transport operators, the capability of railway station areas to become "future-proof" and be able to handle the growing demand for public transport is more important than the ecological resilience of railway station areas.

Third, in discussing smart city components related to human and social capital, it was stated that railway stations are seen as "hubs" for knowledge exchange in the city. Although it was expected that all participants would value the function of railway stations as nodes for people to come together and share their knowledge, this was not strongly expressed in the empirical research. This could be because this smart city characteristic is ranked as less important and/or evident than, for example, technology and (economic) sustainability. Another important aspect related to human and social capital is the accessibility of railway station areas. The "smart" application of automatic gates at the entrances of railway stations highlights a paradox between creating a mixed-use location that "flows" into the rest of the city and keeping the railway station area a "club member area", that is, an area that is only accessible for travellers with a valid public transport ticket for security reasons. In other words, what is smart for some stakeholders may not be smart for others. This relates closely to our fourth conclusion regarding governance. One of the external consultants referred to the railway station area as a "melting pot" of interests, desires and responsibilities. The various responsibilities of the different actors, as described in the paragraph on the results of governance, are complex, which suggests that these parties also have different priorities in managing smart city objectives in their daily practice.

An upcoming discussion in the smart city debate that was noted particularly by the stakeholders in Utrecht and the transport operators in the interviews but has received only minor attention in this paper, concerns the future of open data platforms and the possibility of implementing open data in smart applications. Transparency about how data are being used may help create more willingness among users to "give up" some of their personal data to receive better information. One of the transport operators and one of the external consultants feel that if users know what will happen with their data and how this can affect and help them, they may be more likely to accept the use of some new data technologies. In the context of the Dutch railway station areas, some "best practices" regarding innovation in the use of open data can already be observed. Examples include the "9292ov" multimodal travel planner, the integration of a capacity indicator in the time tables of transport operators, and the integration of real-time delay information in online travel planners. Such applications present a promising picture regarding a more advanced state of implementing smart city objectives in the future. So, although stakeholders seem to be aware of the opportunities that the smart city concept offers them, the widespread implementation of innovative smart city applications remains in the future.

## Acknowledgements

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## Notes

1. 9292ov is an online travel information platform that provides real-time integrated travel information for different modes of public transport.
2. For a thorough discussion on surveillance, technology and safety in night-time public spaces, see Brands (2014).

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## Appendix: List of participants

| Participant | Category | Expertise in this research | Case study area |
|---|---|---|---|
| Municipality of Amsterdam | Municipality | Spatial planning and policy around Amsterdam Central Station | Amsterdam |
| Regional government of Amsterdam | Regional government | Public transport in the region of Amsterdam | Amsterdam |
| Municipality of Rotterdam | Municipality | Spatial planning and policy around Rotterdam Central Station | Rotterdam |
| Regional government of Rotterdam | Regional government | Public transport in the region of Rotterdam | Rotterdam |
| Municipality of Utrecht | Municipality | Spatial planning and policy around Utrecht Central Station | Utrecht |
| Regional government of Utrecht | Regional government | Public transport in the region of Utrecht | Utrecht |
| U-OV/Qbuzz | Transport operator | Public bus transport operator in the region of Utrecht | Utrecht |
| ProRail | Transport operator | Public actor responsible for the redevelopment of railway station areas and "smart" applications | All case study areas |
| NS/Dutch Railways | Transport operator | Public rail transport operator; responsible for smart applications in railway station areas | All case study areas |
| Berenschot[a] | External consultant | Consultancy firm with expertise on smart city aspects | *Expert interview* |
| Vereniging Deltametropool[a] | External consultant | Association of experts with regard to integrated spatial development around transportation hubs | *Expert interview* |
| TNO[a] | External consultant | Research institute with expertise on smart city aspects | *Expert interview* |

[a]Participant did not take part in the Q-methodology exercise.