# Technology Adoption in Smart City Initiatives: Starting Points and Influence Factors

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Abstract: The concept of smart city is considered as a new paradigm of urban development. Information and communication technologies are expected to transform cities into smart cities and improve the citizens' quality of life. However, smart city initiatives still have difficulties to leverage value from technology opportunities. How smart city initiatives start to examine the possibilities of new technologies for smart services is therefore a highly interesting question. Based on a multiple case study we describe two different approaches and identify factors that were crucial for the course of action. As a result, we found on the one hand smart city initiatives that consider the involvement of citizens as essential and start technology adoption from a need perspective. On the other hand, we found initiatives that see new technology and standardized data exchange as a unique opportunity and therefore start with a systematic build-up of technology and data platforms. Innovation adoption research is used as a theoretical basis.

## 1 INTRODUCTION

According to the latest UN forecast, 70 percent of the world's population will live in cities by 2050 (United Nations, 2018). This means that 2.5 billion people will move to urban areas in the next 30 years. Problems such as housing scarcity, overloaded infrastructures and CO2 pollution caused by public transport will continue to worsen as the number of city inhabitants increases. In recent years, numerous smart city initiatives have been launched to tackle these problems (Zelt, 2017). Their aim is to leverage developments in digitization to create new solutions for improving the efficiency of urban services and the quality of citizens' life (Neirotti et al., 2014). The politicians' conviction that technology can contribute to make the city a more liveable and sustainable place is also reflected in the figures of funding programmes. The EU is providing €718 million for smart, green and integrated transport innovations as part of the European Horizon 2020 programme (European Commission, 2018). Such high funding also attract the private sector. Multinational information technology (IT) companies such as IBM or Cisco have discovered the smart city market as a growth driver for their business. These companies offer a variety of integrated solutions for different smart city scenarios (e.g. IBM's Intelligent Waste Management Platform (IBM, 2015)). Collaborations between private and public sectors have also led to criticism of the smart city concept. Brown (2014), Söderström et al. (2014) and Schaffers et al. (2011) criticise them as inefficient and driven by IT vendors. The inefficiency is also criticized by the European Commission (2016) which stated in a working paper, that "city planners, administrators, citizens, entrepreneurs and all other stakeholders must reconsider the way they have approached urban services" to gain value from technology opportunities. Also Anttiroiko, Valkama and Bailey (2014) state that the public sector has difficulty exploiting the value from new technologies. Despite these findings, there have been few attempts in science to understand how smart city initiatives leverage value of new technologies.

The introduction of new technologies is described by innovation adoption theories. The process of innovation adoption typically involves two phases (Rogers, 2003): initiation and implementation. Within these phases, new technologies have to overcome several hurdles before being used productively, i.e. being integrated



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into an existing IT landscape and deployed at full-scale (Fichman, 2000). For technology innovations, the initiation phase, where organizations search for ways to use a new technology, poses a first serious obstacle (Curry, Dustdar, Sheng and Sheth, 2016). This initial step towards the exploration of technology potentials is the focus of our study. In particular we formulate the following research question:

*What approaches do smart city initiatives use when they initially explore the potential of new technologies for smart services and which factors influence their choice of approach*?

To address our research questions, a multiple case study with eight smart city initiatives was conducted. The organizational innovation adoption process (Rogers, 2003) in combination with the Technology-Organization-Environment framework (TOE) (Tornatzky, Fleischer and Chakrabarti, 1990) and the push-pull theory (Schon, 1967; Zmud, 1984) has been used as a theoretical foundation. The TOE describes the impact of technological, organizational and environmental aspects on organizational decision-making with respect to technology innovations (Tornatzky et al., 1990). The push-pull theory distinguishes innovation adoption approaches in a technology-push and need-pull driven perspective (Schon, 1967; Zmud, 1984).

This paper is organized as follows: The current research on technology adoption research in smart city is summarized in the next section. Section 3 presents our conceptual framework. Section 4 introduces the research design. Section 5 presents the findings from our smart city cases. A discussion of the results in section 6 and a summary of the main points in section 7 complete this work.

## 2 CURRENT RESEARCH

The term "Smart City" has been widely used in academia, consultancies and governments. Nevertheless, there is still a lot of confusion on what it really means to be a "smart" city (Caragliu, Bo and Nijkamp, 2009; Nam and Pardo, 2011; Angelidou, 2017). According to Anthopoulos, Janssen and Weerakkody (2016) a smart city is an innovative city that uses information and communication technology to improve citizens' quality of life and the efficiency of urban services. To meet these goals, smart cities need to introduce new technologies and realize smart services that address the concerns and needs of citizens (Anthopoulos et al., 2016; Pourzolfaghar and Helfert, 2017).

Smart services are considered as core element of a smart city and understood as an outcome of innovation (Anthopoulos et al., 2016). The term summarizes the services that a smart city delivers to its stakeholders by the use of the city's intangible resources (e.g. people, knowledge, methods) and tangible resources, in particular information systems, data, and corresponding technologies (ITU-T Focus Group on Smart Sustainable Cities, 2014; Anthopoulos et al., 2016; Angelidou, 2017).

Previous work in the context of technology adoption in smart cities is still scarce and focuses primarily on influencing factors. These are either investigated for the general adoption of the smart city concept or for the adoption of a specific technological solution. For example, Neirotti et al. (2014) used in an empirical analysis a sample of 70 cities to investigate context variables that support the adoption of the smart city concept. As a result, they show that economic development and structural urban variables (e.g. demographic density, city area) drive the initiation of smart city programs in urban areas. Nam and Pardo (2011) and Caragliu et al. (2009) argue that a successful adoption of the smart city concept depends on investments in human and social capital, investments in modern and traditional infrastructure and the participation of citizens. Batubara, Ubacht and Janssen (2018) use the TOE to describe main challenges in the adoption of blockchain technologies in smart cities. As a result, it has been shown that a lack of legal and regulatory support and new governance models are considered as main barriers of blockchain adoption.

So far an investigation of the technology adoption process in smart cities has only been carried out by van Winden and van den Buuse (2017). They used a multiple case study to investigate the implementation phase of smart city projects. Based on twelve smart city initiatives they identify three types of full-scale deployments in smart city projects: roll-out, expansion, and replication. They also identify corresponding influencing factors, e.g. upscaling in the implementation stage is often hindered by an absence of knowledge transfer, a lack of funding and missing standards such as data models or IT systems.

In comparison to existing studies, our research focuses on the initial phase of innovation adoption. We investigate how cities initially explore the potential of new technologies for smart services and factors that influence their choice of approach.

# 3 CONCEPTUAL MODEL

The goal of this research is to describe how cities approach new technologies for smart services in the initiation phase of innovation adoption, and whether there are factors that have a significant impact on their choice of approach.

For our study, we use the innovation adoption process (Rogers, 2003), the push-pull theory (Schon, 1967; Zmud, 1984), and the TOE framework (Tornatzky et al., 1990).

According to Rogers (2003), the process of innovation adoption is described by two major phases: initiation and implementation, with both phases being separated by an adoption decision. The initiation phase consists of the stages agenda-setting and matching and covers all activities that are necessary to explore the capabilities of an innovation. If advantages are expected, the implementation phase is triggered and all activities and decisions necessary to deploy an innovation at full-scale are carried out (Rogers, 2003).

Following the push-pull theory, innovation adoption is either approached form a technology-push or need-pull perspective (Schon, 1967; Zmud, 1984; Di Stefano, Gambardella and Verona, 2012). The technology-push perspective describes the driving force behind the adoption as the expectation of enhancing performance by introducing new technologies (Chau and Tam, 2000). The need-pull perspective describes stakeholder needs as a key driver for the adoption of new technologies (Chau and Tam, 2000).

To investigate the factors that influence the decision on how to approach in the technology adoption, the TOE provides a good theoretical foundation. The TOE describes the factors influencing the adoption of technology innovations. These factors are clustered into three dimensions: technology, organization and environment (Tornatzky et al., 1990). The technology dimension encompasses the characteristics of available technologies which are relevant to an organization. The organizational dimension covers organizational attributes, such as size, formal and informal linking structures, competencies and the amount of slack resources. The organization's environment and its influence are described in the environmental dimension. It includes competitors, industry specifics and regulation. As a very generic framework, the TOE is extensively used in adoption research (for examples see e.g. (Oliveira and Martins, 2011; Baker, 2012)) and can be adapted to different research contexts in a straightforward way (Baker, 2012). For our research the technological dimension reflects attributes describing existing and new technologies that are relevant for a smart city. The organization dimension covers organizational aspects of the city and its smart city initiative. The environment dimension describes the influence of the multiple stakeholders that surround a smart city.

In conclusion, the conceptual framework used in this research combines the initiation phase of the innovation adoption process (Rogers, 2003), the push-pull theory (Schon, 1967; Zmud, 1984) and the TOE (Tornatzky et al., 1990), as shown in figure 1.

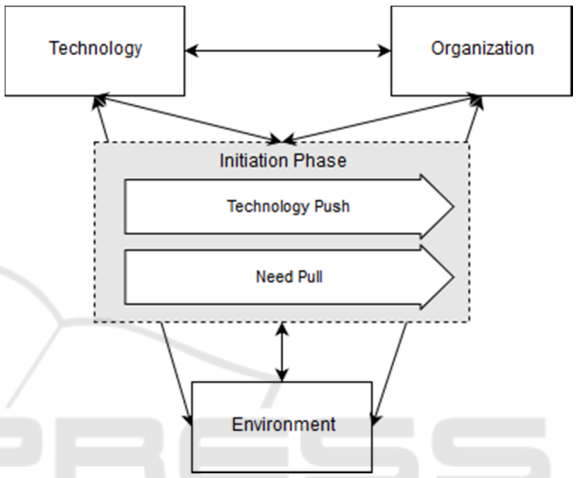


Figure 1: TOE framework.

# 4 RESEARCH DESIGN

This study uses a qualitative research methodology because we have little understanding of how cities explore the potential of new technologies for smart services and why they choose certain strategies. A qualitative approach allows us to obtain detailed descriptions of adoption behaviour. For our research purpose, we choose a case study method. This method is especially appropriate whenever research deals with "how" and "why" questions and facilitates analyses of contemporary phenomena in a real word context (Benbasat, Goldstein and Mead, 1987; Darke, Shanks and Broadbent, 1998; Dubé and Paré, 2003; Yin, 2003). Our main information sources are in-depth expert interviews with key-informants (i.e. smart city representatives) and public documents from smart city initiatives.

In the sense of a strict implementation of the research design, four established quality criteria were used (Yin, 2003): external validity, internal validity, construct validity and reliability. The external validity focusses on the generalizability of

the results. This is ensured by replicating the case studies. Therefore we selected a multiple case study design following the "literal replication logic". The literal replication logic ensures an analytical generalization by selecting cases from a similar contextual background to predict similar results (Dubé and Paré, 2003; Yin, 2003). In order to ensure a comparable organizational and technological context, we followed the smart city conceptualization of Angelidou (2014) and selected existing major European cities with matured infrastructure. In addition, the selected cities and corresponding smart city initiatives have been validated by the smart city framework of Giffinger (2007), which consists of six main components (smart economy, smart people, smart governance, smart mobility, smart environment, and smart living). Against this background, we selected only cities which are active in at least two categories.

Table 1 shows the cases under study.

Table 1: Participants of case study.

| # | City | Role of Interviewee |
|---|---|---|
| 1 | Amsterdam | Program ambassador |
| 2 | Barcelona | Catalan smart city coordinator |
| 3 | Dublin | Smart city coordinator |
| 4 | Cologne | Smart city project manager |
| 5 | Copenhagen | Head of IT |
| 6 | Berlin | Policy advisor smart city |
| 7 | Vienna | Expert for urban innovation |
| 8 | Zurich | Deputy director urban development |

Following Eisenhardt (1989), an a priori specification of constructs helps researchers to shape the initial design of theory-building research. In order to ensure internal validity, we followed this argumentation and developed the interview guideline on the basis of the conceptual framework described in section 3 of this paper. The expert interviews were semi-structured and we kept our questions open to allow interviewees freely to speak. The first part contained general questions about the role and responsibility of the interviewee and the general goals of the smart city initiative. The second part of our questions concentrated on activities related to the beginning of technology adoption. For example, we asked how specific needs for technology innovations are recognized, how they are prioritized and whether specific objectives for technology adoption exist. We also asked about factors that have influenced the first decisions about dealing with new technologies. Hereby we covered in particular the TOE dimension of our conceptual model. The third and most extensive set of questions was directed upon "why" and "how" the initiatives explore the potentials of new technologies. These questions concerned, e.g. the methods and challenges during the identification of technology opportunities, the evaluation of technology potentials and the criteria applied therein.

Yin (2003) suggests triangulation to ensure construct validity. Within the case studies, different data sources were therefore used. In addition to the key-informant interviews the rich body of public documents of smart city initiatives was analysed to validate the information retrieved from the key-informant interviews. Table 2 provides an overview of case information sources.

Table 2: Information sources.

| Data source | Description |
|---|---|
| Interviews with smart city representatives | 13 interviews were conducted (8 key informants + 5 supplementary interviews with other smart city officials) |
| Publicly available documents from members of the smart city initiative | 151 technology adoption related press articles, blog entries, white papers, annual reports and conference presentations were screened |

In order to minimize errors and biases, the reliability of the case study analysis was ensured by establishing a case study database. There, we stored all information about the data collection process, the data itself and the case study results. According to Yin (2003), this helps to provide the same results in repeated trials and makes the data available for independent inspections.

The data collection started in February 2018 and stretched over a period of five months. The conversations were recorded and transcribed. Shortly after each interview, the main points and key findings were recapitulated in a contact summary sheet (Miles, Huberman and Saldana, 2013).

The analysis of the cases was carried out in a twofold way. First, we have used a within-case analysis (Yin, 2003) to extract all characteristic content (i.e. trigger of the process, activities in agenda-setting and matching) and influencing factors related to the agenda-setting of individual cases. For this purpose, we followed the deductive content analysis method (Mayring, 2008) and used first-level coding (Miles et al., 2013) supported by the software f4analyse. In the second step, a cross-case analysis (Yin, 2003) was conducted and the cases were compared to each other. The results of these analyses are shown in chapter 5 and discussed in chapter 6.

# 5 RESULTS

Innovation adoption can be approached from a technology-push or need-pull perspective (Schon, 1967; Zmud, 1984; Di Stefano et al., 2012). Based on this distinction, we were able to divide the smart city initiatives and their corresponding approaches in the initiation phase into two groups: need-pull and technology-push initiatives. Table 3 and 4 present the cases on the basis of the main case characteristics (i.e. exemplary statements, which were particularly emphasized) and a brief description of the initiatives' first technology adoption activities.

Need-pull smart city initiatives (table 3): initiatives in this category explore technological potentials from a stakeholder-need perspective. They initially focus on the collection of potential applications solving smart city challenges (e.g. through virtual collaboration platforms, design thinking projects). Identified use cases are then evaluated on how they contribute to the superordinate smart city goals (e.g. CO2 reduction through improvements in public mobility). If this is verifiable, corresponding technologies are implemented and the application is tested as a prototype.

For example in case 1, the initiative launched a central web portal to connect different stakeholders, receive user-initiated project proposals (e.g. ideas, how new technologies can be used to solve challenges) and attract people to launch projects as

Table 3: Need-pull smart city initiatives.

| # | Main Case Characteristics | Sample Quote | First Technology Adoption Activities |
|---|---|---|---|
| 1 | ▪ implementation of innovative projects is expected to favour sustainable economic development<br>▪ empowerment of citizens and local start-ups is perceived as important for the identification of potential smart services<br>▪ transparency in political decision on project proposals is perceived as important to increase citizen's engagement | "Co-creating and co-developing urban solutions requires involvement and empowerment of citizens in the innovation process. This should enhance [..] accepted solutions that work and create value for all involved parties, including citizens." (Public Documents) | establish web portal to connect smart city stakeholder; creation of smart city team that asses the user initiated project proposals for potential smart services; focus on smart services that solve city challenges |
| 4 | ▪ no dedicated smart city budget; dependence on third party funds<br>▪ expectation of economic returns by solving city's challenges with smart services<br>▪ coordination and communication of different projects within the city is perceived as important to identify synergies and valuable smart services | "Smart city Cologne is at the same time a coordination and communication platform for various projects for climate protection, energy and transport change and improved energy efficiency." (Interview) | connect the different smart city stakeholders and share plans, strategies, activities between them; utilize design thinking and other creativity methods to identify needs of city stakeholders |
| 7 | ▪ empowerment of the private sector is perceived as important for identification of use cases<br>▪ single focus on smart city technologies is expected to neglect citizen participation and exacerbate the digital divide<br>▪ initial identification of lighthouse use cases is expected to attract further capital and strengthen confidence in the initiative | "In Vienna, a demand-oriented approach [for the introduction of new technologies] is chosen. If a problem requires a new solution, the appropriate means are sought to develop a suitable solution - these of course often include digital or technological components." (Interview) | collect urban problems via app and develop solutions by using concepts like co-creation labs or industry-meets-makers; projects within the smart city Vienna initiative are first developed as pilots using dedicated technologies and data sources; integration aspects are not initially considered |
| 8 | ▪ existing technology infrastructure is perceived as sufficient for current digitization efforts<br>▪ synergies for new smart services are expected by the coordination of municipal companies that are already working on their own digitization projects<br>▪ the creation of "good practices" strengthens confidence in the smart city initiative and promotes motivation to participate | "By comparison, the [technology] infrastructure in Switzerland and here in the city of Zurich is already well developed and will be further optimized." (Interview) | definition of a smart city strategy with focus on the challenges of the city and the needs of city's stakeholders; identification of the needs via innovative methods (e.g. design thinking) and a so-called virtual "participation portal"; development of solutions for the identified needs in collaboration with public and private companies |

pilots. The smart city initiative assesses the project proposals. If the assessment proof successful, the project proposals are conducted as pilots in designated city areas. The lessons learned from the pilots are then used for refinements and a further evaluation whether the goals could be achieved (e.g. people accept the technology, CO2 pollution could be reduced).

Technology-push smart city initiatives (table 4):

In the technology-push approach, cities initially invest in cyber-physical systems (i.e. combination of computational components with mechanical and electronic parts) and develop platforms that integrate different new technologies for data acquisition, integration and storage. These platform capabilities are then advertised and communicated to attract private organizations (e.g. companies, start-ups, local communities) to drive the identification and exploration of use cases for smart services, e.g. through hackathons. This approach often initially concentrates on certain domains of a smart city (e.g. smart transportation, smart energy).

For example in case 6, the connection of innovative technologies with existing infrastructure was one goal of the city's first efforts. Requirements for infrastructure projects were therefore utilized to anchor new technologies (e.g. sensors in lampposts) in the city's infrastructure. In cooperation with state-

Table 4: Technology-push smart city initiatives.

| # | Main Case Characteristics | Sample Quote | First Technology Adoption Activities |
|---|---|---|---|
| 2 | ▪ welfare of citizens is expected to increase due to an open and modern technology platform<br>▪ new technologies are intended to make business processes of public administration more accessible, efficient, effective and transparent<br>▪ synergies are expected by standardized information sharing within the city's companies | "Through investment in IoT for urban systems, Barcelona [will achieve] a wide array of benefits. From reduced congestion and lower emissions, to cost savings on water and power [..]" (Public Documents) | built public private partnership to realize technology platform; systematic development of data platform and integration of different public data sources |
| 3 | ▪ modern technology infrastructure is seen as a unique prerequisite for solving urban problems<br>▪ new technologies are intended to increase the efficiency of the city's overall management<br>▪ building of information systems is perceived as complex | "[Our technology and data] platform should lead to improved economic development by speeding up the advancement of services based on data[..]" (Public Documents) | focus on improvements in the public transportation system and water management; public private partnership to collect and analyse traffic and consumption data; join and integrate existing data bases with newly collected data; provision of smart services based on the acquired information |
| 5 | ▪ availability of data is perceived as a unique starting point for developing smart services<br>▪ modern technology platform is perceived as key for later smart city developments<br>▪ new businesses and a highly skilled workforce are expected to be attracted by a modern technology platform | "The City Data Exchange for Copenhagen is a solution for making public and private data accessible so that the data can help power innovation [..] If we combine data from the private sector and data from the city then it is expected that we can make new solutions and new products out of it." (Interview) | release of a smart plan describing which technologies are needed to get smarter; big data identified as key technology; city data exchange concepted and established based on a public private partnership |
| 6 | ▪ data and information are perceived as essential resources of an information society<br>▪ technology innovations are perceived as complex but seen as unique opportunity for the future development of the city<br>▪ coordination of digitization activities in public companies within the city is perceived as important in order to guide the development of city wide technology and data platform | "We have a supervisory board function in the state owned companies. This means that we can actively discuss and shape guidelines for project contracting." (Interview) | realize existing infrastructure projects with new technologies; systematic anchoring of sensors in the urban infrastructure; open up new data sources for a data driven identification of smart services |

Table 5: Overview TOE factors and link to main case characteristics.

| Technology | Organization | Environment |
|---|---|---|
| ▪ perceived complexity (the use of new technologies is perceived as complex [+] or not [-])<br>▪ technology landscape (existing technology landscape is perceived as sufficient [+] or not [-])<br>▪ information exchange (standardized information exchange is perceived as essential [+] or not [-])<br>▪ unique benefits (it is expected that a modern technology platform supersedes other measures for city development [+] or not [-]) | ▪ financial readiness (dedicated smart city budget is substantial [+] or limited [-])<br>▪ role of smart city initiative (smart city initiative is primarily seen as coordination platform [+] or not [-])<br>▪ economic returns (direct economic (e.g. job creation) returns are expected [+] or not [-]) | ▪ information systems (IS) fashion (the use of new technologies is perceived as important [+] or not [-])<br>▪ citizen involvement (raise citizens' involvement is a primarily goal of city [+] or not [-])<br>▪ role of private sector (it is expected that innovative use cases come from private sector [+] or not [-]) |

owned companies central data storages were built and different data sets were harmonized and integrated. A public-private partnership was utilized to advertise for the data and technology capabilities.

## 6 DISCUSSION

Following the TOE framework we collected all influencing factors from the investigated cases. We then abstracted and assigned them to the appropriate TOE dimensions. The result is shown in Table 5, including brief comments and explanations. As a result we found ten factors describing the influence on how smart city initiatives start with the exploration of new technologies.

Table 6 visualize the factors which had influence on a city's choice of approach. We found that cities with a need-pull approach typically expect that innovative smart services come from private sector and only leverage value when concerns and needs of citizens are considered. In order to link innovations with citizens' needs, the collaboration of smart city stakeholders is perceived as highly relevant. This high perceived relevance of collaboration is also reflected in the governance model of these smart city initiatives. It considers them as a central platform for the coordination of projects between public and private sector. The city's goal to increase the involvement of citizens in urban development also supports the choice to a need-pull approach. For example, in case 7, the smart city initiative argued that the city administration sees the citizen participation as crucial to the success of smart city development. They therefore wanted to enable the city's residents to participate more actively. A collaboration app should contribute to this goal and simplify and foster the communication between city administration and citizens.

A high perceived complexity of new technologies and a low financial readiness prevents initiatives in this approach from creating innovative smart services on their own and emphasizes the dependency on the private sector as external source for innovations. For example, in case 4, the interviewee argued that the financing of projects is a constant challenge as the city does not have a dedicated smart city budget. In order to identify use cases, a public-private partnership was formed. This public-private partnership enabled the smart city initiative to conduct design thinking projects or hackathons.

Initiatives that follow a technology-push approach perceive a standardized information exchange as a driver for innovations from public and private companies. Implemented modern technologies are seen as unique opportunity to increase efficiency of urban services and attract private companies as well as start-ups. The initiatives hope that these companies will in turn create new local jobs and identify and provide smart services. Despite the technology focus of the initiatives in the technology-push approach, the existing technology landscape is perceived as insufficient for future requirements. For example, in case 3, the city stated that new technologies led to

Table 6: Abstracted TOE factors assigned to the different dimensions and cases.

| | need-pull | | | | technology-push | | | |
|---|---|---|---|---|---|---|---|---|
| | **1** | **4** | **7** | **8** | **2** | **3** | **5** | **6** |
| perceived complexity | + | + | + | + | + | + | + | + |
| technology landscape | - | - | + | + | - | - | - | - |
| information exchange | - | - | - | - | + | + | + | + |
| unique benefits | - | - | - | - | + | + | + | + |
| financial readiness | + | - | - | - | + | - | + | - |
| role of initiative | + | + | + | + | + | - | - | + |
| economic returns | - | + | + | - | + | + | + | + |
| IS fashion | + | + | + | + | + | + | + | + |
| citizen involvement | + | + | + | + | - | - | - | - |
| role of private sector | + | + | + | + | + | + | - | + |

improvements, for example in water management (e.g. reduced leakage through automated pressure management), but that there is still a need to increase the sensor network over the city to improve results.

Additionally, we found IS fashion as a general trigger of the adoption process in all observed initiatives as it reflects the hype that surrounds technology innovations such as blockchain or big data. At the same time, these new technologies are perceived as complex. A frequent argument for the perceived complexity was a lack of IT know-how in public institutions and limited financial resources that impedes the acquisition of external knowledge. Furthermore, most of the interviewed initiatives perceived their financial readiness as low and reported that they are highly dependent on regional, national or international funding schemes.

# 7 SUMMARY

In this paper we have investigated through an analysis of eight cases how smart city initiatives start exploiting potentials of new technologies.

We could describe two different approaches for the initiation phase of technology innovation adoption: a need-pull and technology-push approach. In the need-pull approach, smart city initiative focus initially on the identification of use cases for potential smart services that will meet citizens' needs and solve urban challenges. In the technology-push approach, the systematic build-up of a technology and data platform for a future identification of potential smart services is in the centre of first activities.

The choice for a particular approach is influenced by external and internal factors, which could be assigned to the technology, organization and environment dimensions of the TOE. In particular we found three discriminating factors: information exchange, unique benefits and citizen involvement. The perceived importance of standardized information exchange and expected unique benefits of new technologies were crucial for the technology-push approach. An increased involvement of citizens was considered most relevant in the decision for a need-pull approach.

The theoretical and practical contributions of this research are as follows: Our study shows that the innovation adoption process and TOE can successfully be used to describe and understand the exploration of new technologies in smart cities. The study further contributes new factors to the existing IS adoption literature and provides a starting point for further quantitative and qualitative adoption research. From a practical point of view, cities initiating a smart city program can compare their planned activities with the different approaches and drivers identified in this paper, to possibly re-consider their way of action. Providing a method for the identification of use cases for smart services is planned as a next step in our research agenda. The corresponding design-oriented approach will benefit from the insights gained in this study.

We are sensible that our study faces limitations which should be addressed in future research: A possible restriction may result from the point in time of observation. We investigated how smart city initiatives start to adopt new technologies. During our research we have observed that the approaches of cities change over time and can coexist as the initiative progresses. A longitudinal study could help to describe and understand these changes.

Our identified approaches also open the door for further research: On the one hand, a detailed analysis of the processes within the different approaches could help to provide smart cities a suitable method for the successful identification, evaluation and adoption of smart services. On the other hand, the

choice of approach and the impact on the success of smart service implementation could be investigated in order to provide recommendations for practitioners on what approach they should take

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