5-15-2012

PARTICIPATORY URBAN SENSING: CITIZENS' ACCEPTANCE OF A MOBILE REPORTING SERVICE

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Abstract

Urban sensing describes the use of today's mobile devices to collectively gather information about environmental issues of public interest. Such information and communication technology (ICT) tools can enhance current e-government practices by enabling citizens to actively participate in urban decision making and service delivery. Yet, it is widely unclear whether there is a link between the citizens' propensity to participate and the use of urban sensing technology. In this study we draw on technology acceptance literature to propose a model for the acceptance of a mobile reporting service, i.e. a sensing tool for reporting urban infrastructure issues to a municipality. The model explains perceived usefulness of urban sensing by the citizen's degree of environmental awareness *and his/her* willingness to participate *in public affairs. Furthermore, we conceptualize* mobile literacy *as an important antecedent of perceived ease of use. Empirical tests using data from 200 potential service adopters support these ideas. The findings also suggest that for mobile e-government offerings,* perceived privacy risks *are not a significant barrier to adoption. These results provide important implications for theory and practice.*

Keywords: Urban sensing, Citizen participation, E-Government, Mobile government, Mobile reporting, Technology acceptance, Instrument development, Field survey, Partial least squares.

1 Introduction

Urban sensing is receiving high attention as an emerging paradigm in pervasive computing (Cuff, Hansen and Kang 2008). This paradigm refers to understanding today's mobile devices—which are increasingly capable of capturing and transmitting image, audio, location and other data—as well as their users as sensor nodes of large information networks (Burke et al. 2006). Such sensing data can be useful for a broad range of applications of public interest (Johnson et al. 2007, p. 5), such as traffic and pollution monitoring (Kinkade and Verclas 2008, p. 52), environmental impact assessment (Mun et al. 2009), and noise control (Maisonneuve, Stevens and Ochab 2010). Therefore urban sensing may also enhance institutionalized e-government practices by the mobile channel and enable new ways of citizen participation.

Citizen participation is seen as an important building block for accountable and transparent urban governance and has been primarily studied under the aspect of public influence in policy making (Irvin and Stansbury 2004). However, ever since citizens have also been involved in public service delivery and helped to co-produce public value, for example when contributing or non-contributing to the regular activities of government officials (Whitaker 1980; Alford 2002). The enablement of such participation has been described as the highest stage in e-government evolution (Moon 2002). Emerging mobile information and communication technologies, such as urban sensing, allow for new possibilities of citizen participation and thus—given a wide acceptance—may help to reduce costs in both, public decision making and public service delivery (Kumar and Vragov 2009).

A number of recent studies have investigated the citizens' acceptance of e-government services (e.g., Carter and Bélanger 2005; Dimitrova and Chen 2006; Veit, Parasie, and Schoppé 2010) as well as the user acceptance of mobile services (e.g., Wu and Wang 2005; Wang, Lin, and Luarn 2006; Xu et al. 2009). However, few works have addressed the peculiarities at the intersecting domain of *mobile* e-government services, in particular urban sensing. Most notably, the link between the citizens' propensity to participate in urban affairs and the use of urban sensing is yet unclear (cp. Kuznetsov and Paulos 2010). A significant link would be indicative that offering participatory ICT tools is an effective means to enable more citizen participation (while insignificance would suggest that acceptance rather depends on other factors such as opportunistic motivations or enjoyment). Hence, we formulate our research questions: *a) How can we explain the citizens' acceptance of an urban sensing application* and *b) Is there a link between citizens' willingness to participate and the use of urban sensing applications?*[1] These questions are of crucial importance not only from a research perspective, but also for urban decision makers planning to implement participatory ICT tools.

In this work we investigate the user acceptance of a *mobile reporting service*, i.e. a participatory sensing application that enables citizens to report urban infrastructure issues such as potholes, waste and other defects. By the use of a mobile device, such report can be sent to the local authority directly on the spot, ideally tagged with a photo and according location coordinates. We chose this practical example of urban sensing as there are first mobile reporting applications (apps) available in the real-world. For instance, in Germany currently an increasing number of cities implement such service as an integral part of their mobile e-government offerings (Vitako 2011, p. 11). Moreover, independent private or semi-public service providers are pushing into this market and potentially cooperate with municipalities in offering web platforms that can be accessed by government officials as well as the citizens' mobile devices.[2]

As a theoretical framework for our study we draw on the seminal literature on technology acceptance (Fishbein and Ajzen 1975; Davis 1989; Venkatesh and Davis 2000; Venkatesh et al. 2003; Gefen,

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[1] This work focuses on the *intention* to use urban sensing, however, this is inherently linked with the *actual use* (Davis 1989)
[2] Examples are amongst others City Sourced (US), FixMyStreet (UK), Mark-a-Spot and WDW-Anliegen (Germany)

Karahanna, and Straub 2003) and combine our research model with appropriate constructs from e-government and mobile commerce research. To capture the unique characteristics of participatory urban sensing, we theoretically develop the new antecedent constructs *environmental awareness*, *willingness to participate* as well as *mobile literacy*. Empirical tests using data from 200 potential adopters support the validity and predictive power of all three constructs, which allows for interesting implications from a theoretical and a practitioners standpoint.

In the remainder of this paper we will first review the theoretical foundations and develop our research model. In Section 3 we explain our methodology, the measurement instrument and sample characteristics. Section 4 analyses and discusses the empirical results. Finally, Section 5 concludes by outlining the implications, limitations, and future work.

2 Theoretical Foundations and Model Development

Since urban sensing is a relatively new phenomenon, we root our research in the widely accepted technology acceptance model (TAM) by Davis (1989). TAM has been proven to provide robust predictions of intended use, even if a technology is not yet fully available to its prospective users (Sheppard, Hartwick, and Warshaw 1988). The overall research model is depicted in Figure 1.

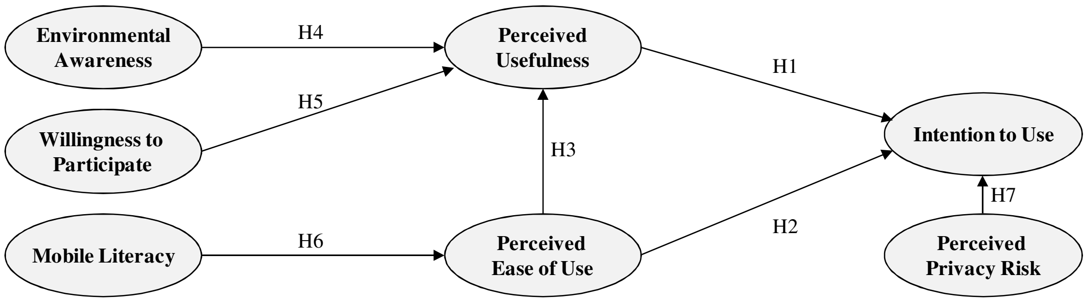


Figure 1. Research Model

2.1 Technology Acceptance in Urban Sensing

Urban sensing can be regarded as a class of information and communication technologies that are embedded in a whole system of actors and artifacts. Such system would typically consist of the citizens, their mobile devices running the urban sensing application, a central server processing messages from the citizens, and a website presenting according information to citizens and recipients of the urban administration. The citizens' individual decision of adopting (i.e., installing the application on his or her mobile device) and using such technology (i.e., sending reports when encountering an infrastructure issue) can be explained by drawing on TAM.

TAM has been developed by Davis (1989) based on the theory reasoned action (TRA, Fishbein and Ajzen 1975) and was found to be a robust theory for explaining technology adoption on user level. With regard to technology adoption, TRA essentially states that beliefs about information technology influence the user's attitudes, which subsequently lead to behavioural intentions and actual technology usage. According to TAM, beliefs about information technology can be attributed to the two dimensions perceived usefulness (PU) and perceived ease of use (PE). TAM provides that both constructs may be influenced by further external variables that capture specific beliefs about the respective technology (Davis 1989). Numerous adaptations and extensions of TAM have been proposed (see Legris, Ingham and Collerette 2003; Yousafzai, Foxall, and Pallister 2007 for overviews). Particularly the user's attitudes and their mediating influence have been removed from the model in a later revision (Venkatesh and Davis 2000).

Despite its origin in organizational contexts—where the users of a technology are typically employees—TAM has also been transferred to the adoption of diverse non work-related technologies (e.g., Gefen et al. 2003). In such voluntary settings, the influence presented by subjective norms has been found to be less significant (Venkatesh and Davis 2000; Venkatesh et al. 2003). The scenario of an urban sensing application offered by a local municipality represents such a voluntary setting. It can be attributed to the intersection of mobile commerce and e-government, an emerging field that has also been termed as mobile government (Kushcu and Kuscu 2003; Winkler, Lvova, and Günther 2011). We will draw on the literature in both intersecting fields to develop our research model.

2.2 Intention to Use, Usefulness and Ease of Use in Urban Sensing

Since urban sensing is a rather new phenomenon, we focus on the intention to use (IU) as the dependent variable of this research. According to TRA, behavioral intention can be interpreted as the *subjective probability that a person will perform a specific behaviour,* e.g., *to adopt an urban sensing application* (Fishbein and Ajzen 1975). Although individuals tend to overestimate their intended use, is has been shown that this variable strongly correlates with the later adoption and use of a system (Sheppard, Hartwick, and Warshaw 1988; Davis 1989).

Perceived usefulness (PU) can generally be defined as *a measure of the individual's subjective assessment of the utility of an information technology in a specific task-related context* (Gefen et al. 2003). In case of a citizen and the voluntary use of urban sensing, perceived usefulness may refer to the individual task-related context as well as to the broader collective utility of an urban context. Individual utility relates to convenience, efficiency and effectiveness when reporting issues directly on the spot via a mobile device, compared to the traditional ways of reporting, i.e. by phone calls or emails to the urban administration. Consequently, collective utility is generated if the collective usage leads to according effects on the overall quality of living, e.g. through a cleaner environment and a higher responsiveness of the urban administration. That is, we are not restricting perceived usefulness to an individual performance expectancy of the citizen (Venkatesh et al. 2003), but also consider the idea of collective usefulness and public value within this construct (Alford 2002, p. 33). Some authors argue that inclusion of such domain-specific characteristics in PU can provide a better understandability of the overall model (Yousafzai et al. 2007, p. 300). In line with TAM we pose

H1: Perceived usefulness (PU) will positively affect the intention to use (IU) urban sensing.

According to Davis (1989), perceived ease of use (PE) is defined as *the degree to which a person believes that using a particular system would be free from effort*. Ease of use is also one of the central goals in human computer interaction and usability engineering (Nielsen 1994). Usability can be achieved by creating systems that are easy to understand, easy to remember, efficient to use, and subjectively pleasing (Nielsen 1994, p. 26). Regarding a mobile application for urban sensing, this may refer to user interface design as well as the usability of the mobile device itself. It has been shown that users largely base their usability assessment on general beliefs and previous experience, especially for technologies that are new to them (Venkatesh et al. 2003). Therefore system-independent factors are at least equally important to objective usability criteria for the ease of use perception. According to TAM, perceived ease of use not only influences the intention to use (IU), but also perceived usefulness (PU). That is, the easier an urban sensing application is to use, the more useful it can be. We pose:

H2: Perceived ease of use (PE) will positively affect the intention to use (IU) urban sensing.

H3: Perceived ease of use (PE) will positively affect the perceived usefulness (PU) of urban sensing.

2.3 Antecedents of Perceived Usefulness in Urban Sensing

TAM provides that the core constructs (PE, PU) may be explained by external variables which are more specific to the technology (Davis 1989). Urban sensing applications can be regarded as large information networks (Burke et al. 2006). Social network theory provides that the behaviour of each of the nodes within this network can be characterized by opportunistic or altruistic behaviour (Hui et al. 2009). We build on this dichotomy and propose two antecedents for perceived usefulness: environmental awareness (EA) and willingness to participate (WP).

Environmental awareness (EA) refers to the opportunistic motivation for using urban sensing. The fundamental idea of urban sensing is to capture and counteract environmental issues such as traffic, noise, or infrastructure defects (Burke et al. 2006). Yet, citizens presumably differ in their perception of the urban environment. Therefore we define environmental awareness (EA) as *the degree to which an individual is concerned about the physical state of his/her direct urban environment*. Those citizens who are highly aware about their environment will possibly find an urban sensing application more useful, because they have an inherent interest that irregular environmental issues be corrected. In a wider sense this construct can also be related to performance expectancy in an organizational context (Venkatesh et al. 2003; Gefen et al. 2003). That is, the urban sensing application helps environmental-aware citizens to better perform their context-related task of reporting an issue. We pose

H4: Environmental awareness (EA) will positively affect perceived usefulness (PU) of urban sensing.

Willingness to participate (WP) is the central construct of this research and captures a more altruistic motivation for using urban sensing. Alford (2002) identifies willingness as the principal reason for citizens to participate and coproduce public value. Based on this, we define the willingness to participate as ***the degree to which an individual wants to participate in public affairs and urban decision making*** (no matter by which means). In Political Science, participation is regarded as one of the core aspect of civic engagement for society (Dimitrova and Chen 2006, p. 177). Yet, in the Information Systems field few works have explicitly considered this construct to explain e-government adoption—a fact that may as well call for more interdisciplinary approaches (Carter 2006, p. 9). Carter (2006) explains the adoption of Internet voting through *political motivations* such as political interest, efficacy and mobilization, besides other technological and demographic factors. Dimitrova and Chen (2006) emphasize that *civic mindness* is one of four major factors that influence the intention to use e-government services. Veit et al. (2010) add *political motivation* as new construct to a TAM model for e-participation and social media tools. Their findings suggest that political motivation does not have a moderating influence on the relationship between EU and IU, but significantly influences adoption of e-participation tools as an antecedent of IU. However, these works mostly refer to (a) stationary Internet tools and (b) to the policy making level. We assume that (a) the use of mobile Internet tools (b) on the service delivery level is also likely to be an extension of the citizens' political involvement via traditional channels (cp. Whitaker 1980), and pose

H5: Willingness to participate (WP) will positively affect perceived usefulness (PU) of urban sensing.

2.4 Mobile Literacy and Perceived Privacy Risks in Urban Sensing

Since today's mobile devices are becoming increasingly 'smart', i.e. powerful in functionality and connectivity, they set new requirements regarding basic user skills and trust (cp. Johnson et al. 2007). We include mobile literacy of the user (ML) and the perceived privacy risks towards mobile service providers (PR) as two further constructs of our research model.

Other authors have suggested that the concept of literacy could be an influential underlying mechanism that is currently underrepresented in technology adoption research (Venkatesh et al. 2003, p. 469). Based on the concept of computer literacy (Winter, Chudoba, and Gutek 1997) we define mobile literacy (ML) as *the perceived ability to use 'smart' mobile devices efficiently and effectively*. This conceptualization can ultimately be regarded as a special form of computer self-efficacy (Davis 1989, p. 321). Social cognitive theory provides that users strongly anchor their ease of use perceptions about an information system to their computer self-efficacy, i.e. their perceived ability to use this system (Venkatesh et al. 2003, p. 455). Applied to the context of mobile technology, self-efficacy may refer to perceived skills for browsing the mobile Internet, installing a mobile application and handling touch-screens. Such general beliefs can be derived from own experience (i.e., the use of mobile applications other than urban sensing) or from observations of others (Venkatesh and Davis 2000, p. 192). Accordingly we pose:

H6: Mobile literacy (ML) will positively affect the perceived ease of use (PE) of urban sensing.

Trust and trustworthiness plays an important role in user acceptance of both, e-commerce and e-government systems (Gefen et al. 2003; Carter and Bélanger 2005). Users assess different types of risks when engaging in online activities or transactions (Wu and Wang 2005, p. 722). This effect becomes even more prevalent with the use of mobile services, where location and personalization information may unintentionally be disclosed to a third party (Xu et al. 2009). Inverting the definition for perceived credibility from Wang et al. (2006), we define perceived privacy risk (PR) as *the extent to which a person believes that using a mobile service will not be free from privacy threats*. Literature suggests that individuals perform a privacy calculus in balancing the risks with the outcome they receive as a return for providing personal information (Xu et al. 2009; Krasnova and Veltri 2010)—in case or urban sensing for example location, photo, recording and potentially identifying contact information (Johnson et al. 2007). Therefore, constructs like perceived risk are commonly hypothesized to directly affect the intention to use (e.g., Gefen et al 2003; Wu and Wang 2005; Wang et al. 2006). Accordingly we pose

H7: Perceived privacy risk (PR) will negatively affect the intention to use (IU) urban sensing.

3 Methodology

A field survey was conducted to test the proposed model. Since urban sensing represents a class of information systems rather than a concrete application, we chose a *mobile reporting service*, i.e. an urban sensing application to report urban infrastructure issue (e.g. potholes, waste, and other defects) as a concrete scenario for our survey. In the following we describe our approach to develop the measurement instrument and to acquire a sample of citizen respondents.

Abbr.	Item	M	SD	Load	Sources
IU1	I can imagine to use the mobile reporting service	4.05	1.06	0.90***	Davis 1989; Venkatesh et al. 2003
IU2	I think about using the mobile reporting service	3.55	1.19	0.83***	
IU3	I intend to use the mobile reporting service	3.48	1.26	0.91***	
PU1	A mob. rep. serv. would save time for reporting infrastructure issues	4.25	0.95	0.86***	Venkatesh et al. 2003; Gefen et al. 2003; Alford 2002; and self-developed
PU2	A mob. rep. serv. allows one to report problems on the spot	4.44	0.81	0.82***	
PU3	A mob. rep. serv. allows people to report more infrastructure issues	4.39	0.87	0.83***	
PU4	Overall, I find it useful to have a mobile reporting service for my city	4.17	0.93	0.93***	
PU5^{r}	I think a mobile reporting service would be ineffective for my city	2.02	1.13	0.75***	
PE1	The interaction with this service would be easy for me to understand	4.14	0.98	0.81***	Davis 1989; Venkatesh et al. 2003;
PE2	Using a mobile reporting service would not be much effort for me	3.84	1.17	0.90***	
PE3	Overall, I think that a mobile reporting service would be easy to use	4.04	1.05	0.99***	
PE4^{r}	I find it cumbersome to use a mobile reporting service	2.07	1.12	0.84***	
EA1	I am concerned about infrastructure issues in my environment	4.02	1.02	0.65***	Self-developed; Burke e.a. 2006; Venkatesh et al. 2003; Gefen et al. 2003
EA2	I want any infrastructure issues in my environment to be removed	4.47	0.80	0.85***	
EA3	I am interested in keeping my neighborhood clean	4.48	0.75	0.75***	
EA4	I appreciate if the properties in my city are clean and tidy	4.65	0.69	0.68***	
EA5^{r}	I don't care about infrastructure issues in my environment	1.52	0.86	0.79***	
WP1	I like to have an influence in my city	3.99	0.95	0.73***	Self-developed; Dimitrova and Chen 2006; Carter (2006); Veit et al. 2010
WP2	I like to call the attention of my city on certain grievances	3.96	0.96	0.85***	
WP3	I like to take part in decision-making in my city	3.96	0.94	0.89***	
WP4	I communicate issues to the municipality that I find important	3.24	1.45	0.76***	
WP5^{r}	I don't need any influence in my city	3.94	1.16	0.68***	
ML1	For me it is easy to use internet services on a mobile phone	3.37	1.45	0.94***	Self-developed; Venkatesh et al. 2003; Winter et al. 1997
ML2	I am well versed in using internet services on a mobile phone	2.95	1.52	0.90***	
ML3	I could often use internet services on a mobile phone	2.40	1.66	0.84***	
ML4^{r}	I need help with using internet services on a mobile phone	2.20	1.38	0.69***	
PR1	I think that service providers can abuse user data	4.03	0.96	0.81**; 0.87***	Wang et al. 2006
PR2	I am reluctant to provide personal information to a mobile service	4.07	1.09	0.83**; 0.87***	
PR3	A mobile service can divulge my personal data	3.46	1.39	0.12 ; —	
PR4^{r}	I think that one can trust the providers of mobile internet services	2.31	1.01	0.39 ; 0.54*	

^{r} reverse-coded item; significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table 1. Measurement instrument, descriptive statistics and reliabilites

3.1 Instrument Development

Model constructs were derived based on existing literature operationalized on 5-point Likert scales. New items were developed where necessary, especially for the proposed constructs environmental awareness (EA), willingness to participate (WP) and mobile literacy (ML). Also, established constructs such as perceived usefulness (PU) were complemented by appropriate new items in order to adapt them to the specific context of a mobile reporting service. We targeted at 5 items for each of these new or adapted constructs, 4 items for the more established variables, and 3 for intention to use.

Based on our conceptualization as perceived attributes, all constructs are modelled as reflective latent variables. That means that the causal direction is assumed to point from the construct to the item (i.e., the item *reflects* the true value of the latent variable). In order to allow for later consistency and response bias checks, we formulated one reverse-coded item for each of the constructs (except for IU). The final questionnaire was pretested with fellow researchers as well as potential respondents and revised in a number of iterations. The resulting measurement instrument and originating literature is presented in Table 1. (Original survey items in German language can be supplied on request.)

3.2 Sample Characteristics

The survey was administered online and distributed across the personal networks of the authors. Apart from the model items, it contained a brief introduction to the topic (including a series of images to explain the functionality of a mobile reporting service), questions regarding mobile phone usage and demographic data, as well as the possibility to leave an email address for receiving the later survey results. No further incentives for participation were offered. Special attention was paid to the demographic distribution of the recipients in order to achieve a balanced panel of different occupational and age groups (i.e., not only students).

The response period was three weeks during July 2011. Out of 320 participants who opened the survey, 215 completed all relevant survey questions. Data cleaning was performed carefully to filter for unrealistic or inaccurate answers. Apart from the reverse items, we had included two redundant questions (Do you use a smartphone? no/ yes; Are you planning to use a smartphone? I already use/ I am planning to use/ I might be planning to use/ etc.). 15 respondents did not answer these questions consistently and thus were rigorously removed from the sample. (Note that the term ‘smartphone’ had been defined earlier in the survey, however, using a smartphone was not a prerequisite to participate in the survey.) The resulting distribution of survey respondents’ age and occupational status (53% female, 45% male, 2% not stated; 45% users of smartphones, 55% non-users) is depicted in Figure 2.

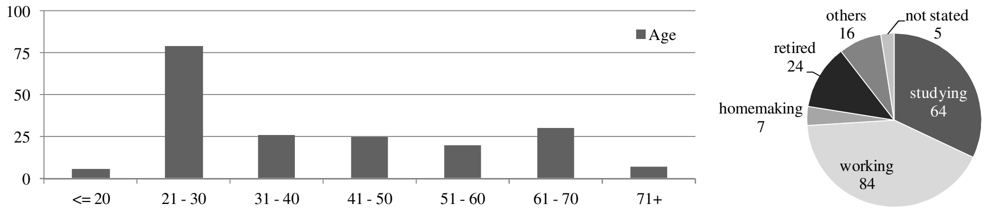


Figure 2. Respondent age and occupation (n=200)

4 Model Analysis and Discussion

We employ partial least squares (PLS) to assess the psychometric adequacy of the measurement model and test the hypothesized structural model. The choice of PLS is motivated by the rather explorative character of this study including three new developed constructs. As Reinartz, Haenlein, and Henseler (2009, p. 341) note, the variance-based PLS is less likely to overestimate relationships between constructs that have potentially not been well operationalized, compared to covariance-based approaches to structural equations modeling such as LISREL. Calculations were performed using the software tools SPSS version 17.0 and SmartPLS version 2.0.M3 (Ringle et al. 2005).

4.1 Measurement Model and Common-Method Bias Assessment

As the first step in the model assessment we evaluate the indicator reliability. Indicator loadings are listed in Table 1. Values should be above 0.7 so that the reflective latent variable explains at least 0.5 ($\approx 0.7^2$) of the variance of each indicator (Chin 1998). This is not the case at least for some of the items adapted from literature (PR3 and PR4). We ascribe the weak loading of PR3 to a confounding phrasing which omits the words "I think", thus asking for an agreement to an act that is actually legally prohibited (i.e., I will typically strongly disagree that "a mobile service" can/ ought to "divulge my data", while I may still see high privacy risks in using it). Consequently, item PR3 is removed from the analysis.

A recalculation in PLS leads to a significant loading of 0.54 in PR4 ($p<0.1$). Also, we note that reverse-coded items largely have lower loadings than their forward-coded counterparts. However, we abstain from removing further items from the measurement model, since all criteria for convergent validity (especially for PR) yield in acceptable values. (For robustness, we also calculated models with strict removal of items PR4, EA1, WP5, and ML4 which did neither change the principal outcomes of the hypotheses tests, nor the relative strengths between the paths of the structural model.) Convergent validity criteria of this revised model are above the recommended thresholds for Cronbachs alpha (Alpha>0.7), composite reliability (CR>0.6) and average variance extracted (AVE>0.5), see Table 2. This indicates that the remaining items sufficiently reflect the properties of their respective constructs (Chin 1998).

Discriminant validity was assessed by three types of analyses: (1) an evaluation of cross-loadings (Chin 1998, p. 321), (2) the Fornell-Larcker (1981, p. 46) criterion as well as (3) an exploratory factor analysis (EFA). (1) The mean of absolute cross-loadings is 0.20 with a maximum at 0.59 (ML1 on PE), thus below the variance-explaining value of 0.7 for direct factor loadings. (2) The Fornell-Larcker criterion, which states that square root of AVE (represented as diagonal elements) should exceed the off-diagonal elements in the construct correlation matrix, is also fulfilled, see Table 2. (3) The results of an EFA (Kaiser-Meyer-Olkin criterion=0.84; eigenvalues>1) support discriminant validity, since the principal components analysis produces seven factors that can be clearly distinguished after varimax rotation (matrix supplied on request). Overall, the assessment of convergent and discriminant validity support the psychometric adequacy of the revised measurement model.

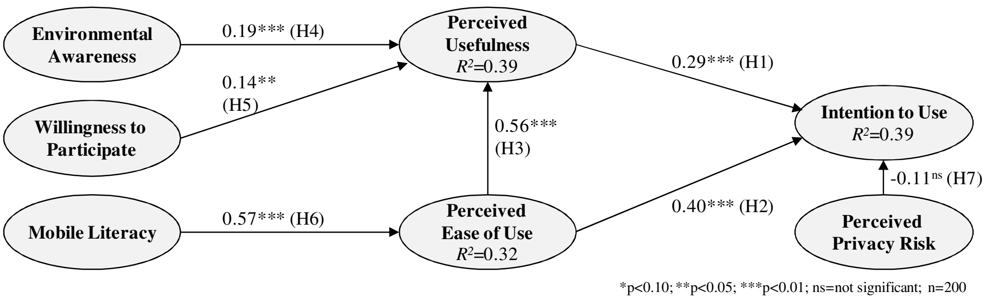
	Convergent validity criteria			Discriminant validity criteria (construct correlations and $\sqrt{AVE}$)						
Construct	Alpha	CR	AVE	IU	PU	PE	EA	WP	ML	PR
IU	0.86	0.91	0.78	**0.88**						
PU	0.89	0.92	0.70	0.52	**0.83**					
PE	0.89	0.92	0.75	0.56	0.56	**0.87**				
EA	0.82	0.86	0.55	0.42	0.30	0.09	**0.74**			
WP	0.83	0.88	0.59	0.28	0.17	-0.07	0.40	**0.77**		
ML	0.86	0.90	0.70	0.29	0.25	0.57	-0.09	-0.06	**0.84**	
PR (incl. PR3)	0.78 (0.76)	0.81 (0.64)	0.59 (0.37)	-0.13	-0.07	0.00	-0.08	-0.08	-0.16	**0.77**

Table 2. Convergent and discriminant validity criteria

As for all self-reported data, there is a threat for a common method bias (CMB) due to the subjects' motif to give socially desirable and cognitively consistent answers (Podsakoff and Organ 1986). We assessed CMB by a Harman's one-factor test (Podsakoff and Organ 1986) as well as a latent method factor approach (Liang et al. 2007). The first factor from the EFA accounts for 0.23 of the total variance (and predominantly loads on the indicators of PU), thus refuting the existence of a single dominant factor according to Harman. Following the procedure described by Liang et al. (2007, p. 85), we included a common method factor in the PLS model comprising all model indicators, and calculated the influence on each principal indicator by its substantive construct and by the method factor. The analysis shows that the average substantively explained variance is 0.69 while the average method-based variance is 0.012 (ratio 44:1). Additionally, after bootstrapping all substantive loadings remain significant (p<0.01) while most path coefficients from method factor are not significant. Altogether these results indicate the method bias is not a serious concern for this study.

4.2 Structural Model Assessment and Discussion

The results of the structural model assessment are depicted in Figure 3. Statistic significance of the parameter estimates (i.e., path coefficients in Figure 3, as well as factor loadings in Table 1) was assessed through T-tests based on a bootstrapping procedure using 1,000 resamples. For the purpose of hypothesis testing, the path coefficients (c) and explained variances (R^2) can be interpreted similar to parameters in a simple regression.



Hypothesis tests	
H1	Supported
H2	Supported
H3	Supported
H4	Supported
H5	Supported
H6	Supported
H7	Not sup.

Figure 3. Structural model results

H1, H2: Perceived usefulness (PU), perceived ease of use (PE) and (with certain limitations) perceived privacy risks (PR) jointly explain R^2_{IU}=0.39 of the variance in the intention to use a mobile reporting service. This level of determination is largely consistent and fully in the range of previous TAM studies (Legris, Ingham and Collerette 2001, p. 200; Venkatesh 2003, p. 441). Yet, in our model the influence of perceived usefulness ($c_{\mathrm{PU}\to\mathrm{IU}}$=0.29***) is clearly weaker than the influence of perceived ease of use ($c_{\mathrm{PE}\to\mathrm{IU}}$=0.40***). This is remarkable since most TAM studies suggest that even in voluntary settings the influence of PU outweights PE (Venkatesh 2003, p. 441; Yousafzai et al. 2007, p. 299). We attribute this difference to the newness of the technology and a lack of concrete user experiences with urban sensing. Several authors have demonstrated that PE is relatively more important in student samples and laboratory settings (Yousafzai et al. 2007, p. 299), while it becomes nonsignificant with increasing experience of the users (Davis et al. 1989; Venkatesh 2003, p. 433).

H3: In line with previous research, the results also demonstrate a strong significant relationship between ease of use and usefulness ($c_{\mathrm{PE}\to\mathrm{PU}}$=0.56***). The explained variance in perceived usefulness R^2_{PU}=0.39 reduces to 0.10 when removing this link from the model, which shows the strong influence of PE on PU (effect size $f_{PE\to PU}$=0.48). Thus, users not only anchor the intention to use, but also their perceived usefulness in their ease of use perceptions of new urban sensing technologies (and similar experiences as we will see further below).

H4, H5: Regarding the antecedents of perceived usefulness (PU), we find that environmental awareness ($c_{\mathrm{EA}\to\mathrm{PU}}$=0.19***) and willingness to participate ($c_{\mathrm{WP}\to\mathrm{PU}}$= 0.14**) are both significant predictors in urban sensing adoption. However, the path strengths indicate that—in the given case of a mobile reporting service—opportunistic goals connected to environmental awareness (i.e., wanting infrastructure issues to be corrected) seem to be more imporant than the altruistic motivation of political participation (i.e., to have an influence in public affairs and urban decision making). This is not surprising inasmuch as a reporting service (and the promise that occurring issues will be taken care of) largely targets the level of service delivery. Nevertheless, other urban sensing applications (e.g., for long-term traffic monitoring or noise controlling), may gather high-level information that targets more at the decision-making level. This underlines the importance of considering willingness to participate (WP) as a dedicated construct within this adoption model of urban sensing.

H6: Mobile literacy is found to be a strong predictor of perceived ease of use ($c_{\mathrm{ML}\rightarrow\mathrm{PE}}$=0.57***). This is in line with the concept of computer self-efficacy derived from social cognitive theory (Venkatesh 2003) and confirms that users largely anchor their ease of use perception in previous experience or observations of others. The strong path coefficient demonstrates that we were able to provide a well-performing operationalization of this construct specifically for the context of mobile technology.

H7: Perceived privacy risks ($c_{\mathrm{PR}\rightarrow\mathrm{IU}}$= -0.11^{ns}) are negatively correlated to intention to use, however, do not significantly affect this construct (effect size $f_{PR\rightarrow IU}$ =0.02). Statistical reasons for this nonsignificant path have been ruled out during the assessment of item reliability (see Section 4.1). Thus, we aim to provide a context-related explanation for this—at first view—counter-intuitive results: Perceived privacy risks have been conceptualized as *the extent to which a person believes that a mobile service will not be free from privacy threats*. Thus, similar to mobile literacy, this construct referred to the *general* perceptions about (public or private) mobile services. In this survey, we described the concrete scenario of a (public) mobile reporting service, i.e. a sensing application that is offered by a local authority. Thus, although the citizen's reporting information may pass a number of third parties (e.g., network providers, platform providers) the recipient remains a public entity. Factor analyses performed by Carter and Bélanger (2005, p. 10) indicate that citizen do *not* clearly distinguish between trust of the Internet and trust of the government when using e-government tools. We argue, that a generally more positive trust attitude towards the local government influences in this relationship, so that privacy risks are not a severe issue for this type of sensing application.

5 Conclusion

In this work we investigated the citizens' acceptance of urban sensing applications, based on the example of a mobile reporting service. For this purpose, we concretized a technology acceptance model (TAM) to our specific context and extended it by the three external variables *environmental awareness*, *willingness to participate*, and *mobile literacy*. Empirical tests employing the partial least squares method (PLS) and data from 200 potential adopters support the psychometric validity and significance of all three constructs. Most prominently, mobile literacy emerges as an important anchor not only for the ease of use perception, but ultimately also for perceived usefulness and intention to use novel mobile services such as urban sensing.

Regarding our focal question, we contend that indeed there seems to be a significant link between the citizens' willingness to participate in public affairs and the use of urban sensing. However, this link is slightly outweighed by the individual's environmental awareness, suggesting that opportunistic and utilitarian motivations will still prevail in the use of urban sensing. Besides these results, we were unable to replicate the findings of previous studies stating that trust, more specifically *perceived privacy risk*, plays an important role in the adoption of mobile services. We attribute this finding to the given scenario of a *municipal* reporting service and conclude that privacy risks seem not to be a significant barrier to adoption of *public* mobile offerings.

These findings provide important implications for practice, foremost for public authorities that are faced with decisions on their mobile e-government strategy. First, the significant link between willingness to participate and perceived usefulness suggests that mobile applications such as urban sensing are not "just toys", but one out of a range of possible tools to enhance citizen participation (Kumar and Vragov 2009). To some extent, this challenges the opinion still prevailing in many in urban authorities that mobile government is just something for "a hand full of younger citizens" (Winkler et al. 2011, p. 10). Second, concerns regarding privacy and data security, which are widely discussed in public sector and often act as a barrier already on decision-making level (Winkler et al. 2011, p. 2), can be largely dispelled based on the given findings. For example, in case a specific municipal mobile service requires entering the user's contact details to ensure proper functionality, this is *not* likely to inhibit the citizens' adoption. Ultimately, attention in the development of mobile government offerings should rather be drawn on the ease of use of these applications, in order to match usability criteria of comparable (commercial) mobile services and thus reach a broad user base.

This work also aims to make a contribution to the research community. Originating from the field of pervasive computing, the comparably young stream of urban sensing has largely been driven by technical considerations and design-oriented works. To the knowledge of the authors, this is one of the first works to investigate user acceptance in urban sensing. We contend that behavioural research on end-user level can complement urban sensing research to allow for a better transition to practice. We concretized the robust and widely applied technology acceptance model (TAM) to the context of urban sensing and demonstrated its use in a specific mobile government scenario. Other researchers may use this model in different urban sensing scenarios and thus facilitate a better understanding of user characteristics and their motivations in this emerging field.

A few limitations of this study merit consideration, foremost related to sample characteristics and generalizability. Although representativeness to a basic population is not a general requirement for correlation-based survey approaches, and variances from voluntary participation were ruled out by common-method bias tests, we still acknowledge that our sample exhibits a notable emphasis on students between 21-30 years. Further, technology acceptance, especially privacy concerns, may be subject to cultural influences. Most of the survey responses were acquired in Germany, a national context with comparably great sensitivity to privacy issues (Krasnova and Veltri 2010). However, the results may still differ in other national contexts, for example due to greater distrust in public governments (Carter and Bélanger 2005, p. 9). Finally, since the focus of this work was on theory development and instrument validation, the model does not explicitly take into account potentially moderating variables such as age, experience, and gender (Venkatesh 2003). In a future work, we hope to conduct a larger study in different national contexts and evaluate the moderating influence of demographic parameters on the adoption of further (public and private) urban sensing applications.

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