Determinants of City Mobile Applications Usage and Success

Rita Pape

EIT InnoEnergy SE, Eindhoven, The Netherlands

ISCTE-IUL, Lisboa, Portugal

rita.pape@innoenergy.com

Carlos J. Costa

Advance/ISEG - Lisbon School of Economics and Management, Universidade de Lisboa, Portugal

cjcosta@iseg.ulisboa.pt

Manuela Aparicio

NOVA Information Management School (NOVA IMS), Universidade Nova de Lisboa, Portugal

manuela.aparicio@novaims.unl.pt

Miguel de Castro Neto

NOVA Information Management School (NOVA IMS), Universidade Nova de Lisboa, Portugal

mneto@novaims.unl.pt

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Rita Pape[1], Carlos J. Costa[2], Manuela Aparicio[3] and Miguel de Castro Neto[3]

[1] ISCTE-IUL, Lisboa, Portugal
[2] Advance/ISEG - Lisbon School of Economics and Management, Universidade de Lisboa, Portugal
[3] NOVA Information Management School (NOVA IMS), Universidade Nova de Lisboa, Portugal

rita.pape@innoenergy.com; cjcosta@iseg.ulisboa.pt¸
manuela.aparicio@novaims.unl.pt; mneto@novaims.unl.pt

Abstract. Smart cities are gaining popularity in local governments as urban regions evolve. The new city paradigm places the citizen at the center of an organic, efficient, interconnected structure. Information and communication technology (ICT) facilitates this change and citizen engagement, and city services and apps are one conduit. This study aims to identify the key variables of city mobile app uptake and performance. We present a study paradigm that was empirically tested in a European city, using an online poll to elicit public feedback on city apps. The results show that perceived usefulness and simplicity of use are significant to city app uptake. These apps also have some net benefits. This study contributes to a new model of city app adoption and supports implementation and development.

Keywords: smart cities, technology adoption, innovation, citizen engagement, gamification, mobile apps, e-government.

1 Introduction

The global population is concentrated in a few cities. These large cities have a higher life expectancy due to their strong economies and urban design. This increase in new citizens (Caragliu, del Bo, and Nijkamp, 2011) causes unpredictability and stress in urban areas. Rapid urbanization complicates planning and management. Transportation, traffic management, food and energy supply, and crowdfunding (Aparicio et al., 2012). Numerous studies have been done on the adoption of new IS and the impact of SC on our society. This study examines the influence of municipal applications on Lisbon's transformation into a Smart City by measuring awareness, enjoyment, usage, and net benefits (city and individual impact). This study surveyed the available literature, beginning with Everett Rogers' Innovation Diffusion Theory (1969) on technology adoption scope and ending with Rob Kitchin's review of the smart city paradigm (2019). Research on smart cities switched to public involvement, e-government, and gaming. Using the literature study results, a research model was built based on Davis' (1989) technology acceptance model and Delone and McLean's IS success systems (2008). Operationalization using a 237-person online survey. For a more comprehensive approach to the research purpose and to organize the survey, a smart city inventory and interviews with city app users were done. After data collection, structural equation modeling and partial least square regression-testing were used for analysis. After model validation, the results were compared to the supporting hypothesis.

2 Theoretical overview

Many have conceptualized a Smart City (SC). A city where smart technology promotes sustainability, safety, comfort, and citizen control. A livable and sustainable city. SC conceptualization gains attention from academia, business, and governments in a quest to describe the new trend of cities composed and monitored by technology (Kitchin, 2014, Mergulhao,et al. 2022), where innovation is the leading agent for both governance and economy, and a new "smart role" of the citizen as the foundation for creativity and entrepreneurship. SC uses digital technologies to improve performance, reduce expenses, increase resource efficiency, and involve residents more actively.

The concept of citizen involvement has evolved (Arnstein, 1969) since the transfer of power to engage individuals in political and economic processes is a cornerstone of democracy and a widely supported principle. The argument that individuals should participate in their governance (Callahan, 2007) appeals to democratic values and is universally acclaimed, yet there is little agreement on how to attain meaningful involvement. Public organizations and government entities use ICTs to open and integrate external stakeholders into their processes (Aparicio et al., 2022). We can thus base the SC on a distinct idea of communication, aligning old infrastructures (telephone, mobile, web access) with new fast data collecting mechanisms (sensors and IoT) that link personal assets to urban architecture (de Castro Neto, Rego, Neves & Cartaxo, 2017). We are going toward integrated device-and-user communication to establish "citizen communication." The transparent, computerized method allows information flow. Citizen communication is crucial for development goals (D'Asaro et al., 2017) and a way to knowledge for government and business. New information sources and frequent exchange affect development potential and access to new options for improving daily life. "E-citizenship" helps shape citizen communication and involvement. Literature urges more research on participatory and collaborative governance (Gustafson & Hertting, 2017) because it's unclear what motivates citizen participation in new governance structures. As we've discussed, ICT has changed top-down management to bottom-up decision-making. Public administration (Khan et al., 2017) has enabled citizen participation in city services and planning by using web-based IT solutions. E-government services include renewing your ID, passport, or driver's license, filing for commercial registration, and controlling your parking meter. Despite improvements and innovations in ICTs to boost the provision of tools and services that allow citizen engagement (Gustafson & Hertting, 2017), adoption is low.

To overcome this difficulty, researchers have studied which parameters can optimize utilization (Aparicio et al., 2021).

Gamification is being used in education, health, and human-computer relations, among other areas (Costa & Aparicio, 2018; Costa et al., 2017; Piteira et al, 2018). Like the SC, the idea has numerous definitions that constrain application rules. Gamification tools (Deterding, 2012) include goal setting, real-time feedback, clarity, proficiency, challenges, and teamwork. The introduction of a new technology may be beyond our control, but its success is. Why do people adopt specific technologies? Regulatory contexts, social pressures, and curiosity have been cited as factors. It aimed to explain how an idea, habit, or product (Rogers & York, 1995) spread through a population or social system. Diffusion occurs in 4 stages (Rogers & York, 1995). Roger and York (1995) say word-of-mouth is the best way to spread a new idea. Age difference affects the use of technology in the workplace due to our society's fast-paced, complicated, and changing work environment (Czaja & Sharit, 1993). Information processing affects older workers' computer-based performance, according to this study. Based on the correlation between age differences and impact on individual adoption and sustained use of technology in the workplace, (Venkatesh, Morris, & Ackerman, 2000) suggests that technology usage decisions are greatly impacted by attitude, and it's more prominent in younger workers than older peers.

3 Model proposal

The proposed research paradigm has three essential components: technology, services, and gamification. The components are all related since municipal applications address both technical adaptation to new concepts and services given to them. We also want to analyze whether gamification influences usage frequency and satisfaction. All three components are supported by 9 constructs: perceived usefulness, perceived ease of use, perceived satisfaction of use, behavioral intention, use, system quality, information quality, service quality, user satisfaction, behavior attitude, individual impact, organizational/city impact, and gamification. Predicting the use of city apps is interesting since they provide communication and services between citizens and the government. Fred Davis' (1989) technology acceptance model proposes analyzing individuals' beliefs, behaviors, and intentions to determine "how" and "when" to adopt new technology. Perceived satisfaction is based on an individual's experiences and beliefs and is the enjoyment of using an application regardless of its performance (Venkatesh, Davis, & Morris, 2007). Information quality and gamification may affect perceived pleasure.

Adoption follows pleasure, happiness, and fun. Gamification adds fun and engagement features (Aparicio et al., 2021; Aparicio et al., 2019; Costa et al., 2017; Piteira & Costa, 2017) to less appealing activities. We expect this layer of enticing and distinctive components to boost app satisfaction and use. Even if studies imply access to relevant information has a limited influence (Urbach, Smolnik, & Riempp, 2010), we expect to gain more insights that support or suggest a different route thanks to ICTs.

Our research focuses on the impact of gamification on city app satisfaction and use. Based on studies by Davis (1989) and DeLone & McLean (2008), the following hypothesis applies to both constructs:

H1a). Information quality improves city app satisfaction.

H1b). City apps benefit from accurate information.

H2a). Gamification improves city app pleasure.

H2b). Gamification improves city apps.

Individuals intuitively assess (Davis, 1989) whether a new solution (technology/service/product) can help them perform better (work, routines, search/access for information, etc.). Therefore, we hypothesize:

H3). Perceived usefulness influences city app usage.

After first seeing a new solution, a person evaluates its usefulness and complexity (Davis, 1989). An individual may believe a solution is of utmost importance (usefulness), but if the use is regarded as tough and complicated, non-use may occur. We expect user-friendliness to affect the adoption of new apps. Hypothesis:

H4). Perceived ease of use influences city app usage.

H5). Intention influences city app use.

According to Urbach et al. (2010), satisfaction and use are interdependent.

The individual effect is also influenced by satisfaction with a solution (Urbach et al., 2010). Hypothesis:

H6). Satisfaction improves city app use.

H7). Apps for cities profit from user pleasure.

H8). Use increases city app benefits.

DeLone & McLean's approach for IS success seems suitable for assessing user happiness with city apps (2008). The individual and organizational impact was indirectly affected by system and information quality due to user satisfaction and use (Petter, DeLone, & McLean, 2008). A further assessment of the model added System quality, Information quality, Service quality, System use, User happiness, and Net benefits. This multifaceted, interconnected model is a solid framework for measuring IS success.

4 Methodology

This study's research model was validated quantitatively.

All model constructs were validated based on literature analysis and empirical studies. Randomly selected Lisbon individuals were interviewed to fine-tune the item structure and validate the model's design. The model constructs were tested using a Likert scale (1 = strongly disagree, 4 = does not know, 7 = strongly agree) with a framework of 56 items examining 14 elements of technology adoption and gamification. After reviewing all inputs and instructions, the validation survey was sent. Lisbon was the study city. The poll was randomly distributed through social media to reach active adults who live, work, or study in Lisbon, as well as varied educational, social, age, and gender audiences. From April 2018 to August 2019, replies were collected.

During this time, 237 answers were received, 31.6% said they don't use city app, 68.35% said they do, for a total of 162 responses, however only 88 were valid. Cohen (1992) recommends 75 samples for PLS-SEM with two correlations per concept and 80% statistical power. Since we have 88 samples, we predict 1% significance and 0.25 R2. According to Fornell and Larcker (1981), a model has convergent validity if AVE is more than 0.5. For all constructs, AVE is between 0.63 to 0.807, suggesting the model exhibits convergent validity.

Table 1 - Evaluation of the measurement model

	Indicator Reliability	Composite Reliability	Average Variance Extracted (AVE)	Cronbach's Alpha
Gam	0,925	0,935	0,706	0,916
IQ	0,863	0,906	0,708	0,861
Intention	0,752	0,884	0,792	0,738
NB	0,914	0,93	0,657	0,911
PEOU	0,835	0,874	0,636	0,814
PU	0,801	0,875	0,702	0,784
PercSatisfact	0,889	0,926	0,807	0,881
UseA	0,799	0,871	0,773	0,717

Once the model verifies convergent validity, we progress to evaluating the reliability of the data collected. If both the composite reliability and Cronbach's alpha are superior to 0,6 (Hair Jr et al., 2014) the data collected is considered reliable. As seen in table 1 the composite reliability ranges from 0,871 and 0,935 and Cronbach's Alpha from 0,717 and 0,916, therefore we can assume the reliability of the data.

For the evaluation of the structural model, we analyzed the determinant coefficients of Pearson (R2) and the significance.

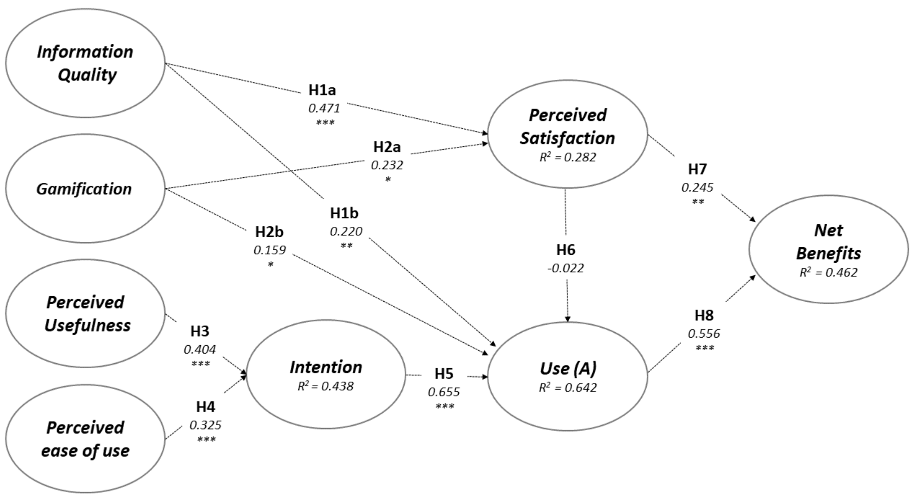

Figure 2 – Structural model results of smart cities mobile applications success

For our study, the R2 of our dependent variables are 0,438 for the Intention of Use, 0,282 for Perceived Satisfaction, 0,642 for Use, and 0,462 for Net benefits.

Table 2 - Structural model evaluation

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Statistical significance
Gam → PercSatisfact	*0,232*	*0,238*	*0,123*	*1,886*	*0,059*	*Positive**
Gam →UseA	*0,159*	*0,159*	*0,088*	*1,801*	*0,072*	*Positive**
IQ → PercSatisfact	*0,471*	*0,469*	*0,077*	*6,085*	*0*	*Positive****
IQ → UseA	*0,22*	*0,212*	*0,09*	*2,433*	*0,015*	*Positive***
Intention → UseA	*0,655*	*0,654*	*0,086*	*7,634*	*0*	*Positive****
PEOU → Intention	*0,325*	*0,328*	*0,109*	*2,979*	*0,003*	*Positive****
PU → Intention	*0,404*	*0,411*	*0,109*	*3,701*	*0*	*Positive****
PercSatisfact → NB	*0,245*	*0,243*	*0,109*	*2,24*	*0,025*	*Positive***
PercSatisfact → UseA	*-0,022*	*-0,015*	*0,066*	*0,337*	*0,736*	*Non-significant*
UseA → NB	*0,556*	*0,562*	*0,1*	*5,565*	*0*	*Positive****

Note: * – significance at $p < 0.10$; ** – significance at $p < 0.05$; *** – significance at $p < 0.01$

Regarding the direct effects of the significance of the path coefficients (Puklavec, Oliveira, & Popovič, 2018), the results suggest that the hypothesis that Perceived satisfaction positively influences the Use of city apps (H6) should be rejected ($p > 0,10$) but the impact of perceived satisfaction on net benefits (H7) is positive and significant ($p < 0,05$). Gamification has positive and significant paths to both perceived satisfaction and use ($p < 0,10$). Information quality has positive and significant paths to perceived satisfaction and use ($p < 0,05$). Perceived usefulness ($p = 0$) and perceived ease of use ($p < 0,01$) have both a positive and very significant impact on intention of use. The intention of use also has a very significant and positive impact on the use of city apps ($p = 0$). Finally, the hypothesis Use is a predictor of net benefits (H8) with significant and positive impact (Table 2).

5. Discussion

This research aims to determine the success characteristics of city applications by designing and implementing an adoption model based on the technology adoption model (Davis, 1989) and the information system's success model (Petter et al., 2008). Studies of employee portal success (Urbach et al., 2010) employing IS success models addressed information quality's limited impact on reported satisfaction. Numerous studies, such as ERP adoption (Costa, Ferreira, Bento, & Aparicio, 2016) and online programming course adoption, have noted the importance of these two elements (Piteira, Costa, & Aparicio, 2017). Perceived satisfaction (-2.2%) doesn't affect city app use. In IS adoption research, the intention of use is significant (Costa et al., 2016; Piteira et al., 2017). The low impact of information quality has been identified in the previous adoption and modeling studies (Aparicio, Bacao, & Oliveira, 2017; Aparicio et al., 2019; Petter et al., 2008), but the impact of gamification elements on use is still being studied (Aparicio et al., 2019; Looyestyn et al., 2017) with positive results. The organization and individual impacts were merged into the net benefits construct as it reflects the success of city apps and is supported by De Lone & McLean (2008) with strong correlations on their measurement of IS success, Urbach et Al (2010) on employee portal success, and Aparicio et al. (2017) on e-learning success.

6. Conclusions

The literature review highlights Smart Cities' impact on metropolitan governance. It also emphasizes how innovative ICTs drive this paradigm shift. The transition to a decentralized governance model in the SC, where the citizen is at the center and resources and infrastructure are efficiently managed, requires new communication and engagement channels, including mobile and web services and applications. This study developed a model to predict the technology adoption and individual and organizational advantages of city services and applications. The model includes information quality, gamification, perceived usefulness, perceived ease of use, intention to use, perceived satisfaction, use, and net benefits. The online survey represented Lisbon's demographics and app users' insights. Data collected validated measurement and structural model results. Perceived usefulness influences intention and use, which contributes to the net benefits of city apps. The inclusion of gamification components had a minor impact on city app usage and satisfaction, suggesting it may not be significant when building and communicating a new city service. These findings help promote city apps. This model explains 46% of smart cities' mobile success. App usage and customer satisfaction determine success. Apps' quality information and gamified features make citizens happier. Information quality and gamification boost app usage. Perceived usefulness should be a differentiator to ensure customer pleasure and uptake. The intention of use occurs when a user has a clear picture of how an app can help him/her with a certain job. The clearer the message, the more use is encouraged.

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