End-User Approach to Evaluating Costs and Benefits of Smart City Applications

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ABSTRACT

As a part of an ongoing series of studies in the smart city domain from the perspective of end-users, the paper presents the results of an exploratory survey based on the cost-benefit analysis of different smart city solutions from users’ point of view. Starting from a list of benefits and costs for four selected smart city applications (smart parking, water quality monitoring, air quality monitoring, and real-time traffic monitoring) that was generated by a young demographic of (future and current) users, a survey was organised to classify, reduce, and evaluate the initial set of items. The respondents rated the identified potential benefits and costs of using the applications as a part of an integrated smart city solution. The results of a multivariate analysis based on the feedback from over 200 participants are presented in the paper. The main factors of identified perceived costs and benefits are indicated, and the link with the intention to use an integrated smart city application is reviewed.

KEYWORDS

Cost-Benefit Analysis, End-Users Perceptions, Integrated Smart City Solutions

INTRODUCTION

In the digital transformation of cities, making the information available and usable to relevant stakeholders is increasingly gaining importance. New studies call for expanding smart city research from the users’ perspective, focusing on psycho-social dimensions of smart city services and applications (Lytras et al., 2021) and emphasise the relevance of citizen-oriented, i.e. user-oriented approaches in the development of smart city applications (Singh and Singh, 2018). However, lack of user involvement in the public sector and underdeveloped user-(citizen-) orientation have been acknowledged extensively (Ninčević Pašalić, Ćukušić and Jadrić, 2020; Verdegem and Verleye, 2009; Tan, Benbasat and Cenfetelli, 2013). The issues resulting from insufficient consideration of users’ needs cause problems with applications not being accepted nor used in this specific context (Tomitsch, 2018). Consequently, studies emerge that focus on behavioural intention, i.e. intention to use a digital service or an app and uncover key elements of its provision in the public sector. Results imply that future studies on smart city services should focus on how those digital services are being delivered to end-users and whether these digital services meet citizens’ needs at all (Wang et al., 2010; Bertot and Jaeger, 2006). In general, the authors noted a general lack of statistical or empirical rigour,
formal theory testing or robust model building in the context of smart cities, especially in terms of usage level, although there is a practical and scientific need (Wirtz and Kurtz, 2016).

Motivated by the presented argumentation, this paper examines possibilities for applying the end-user approach in the form of Cost-Benefit Analysis (CBA), which has been often neglected to evaluate the costs and benefits of smart city applications. In addition, results are being used to explore factors predicting the intention to use. The following research questions have been derived: How can CBA be used for examining factors influencing the intention to use smart city applications? Which factors can predict the intention to use smart city applications? The goals of this paper are: (1) use the CBA framework as an end-users approach for evaluating smart city applications; (2) devise an instrument based on CBA results (2) identify variables that predict the intention to use smart city applications. Research models commonly used for that purpose are presented in the theoretical background along with the elaboration of why a complementary approach that focuses on cost-benefit for users is more appropriate in predicting their intention to use a digital service. The next section elaborates the research methodology aiming to identify the most significant costs and benefits, and factors that could predict the intention to use selected smart city applications. The study results are presented in the following section, followed by a discussion and main conclusions of the paper.

**THEORETICAL BACKGROUND**

**User Acceptance Models in Smart City Research**

Several models focus on the evaluation of acceptance and success of different technology solutions or applications. One of the more pertinent ones is the Technology Acceptance Model (TAM) developed by Davis (1989). It became the dominant model for investigating user acceptance factors (Maranguníć and Granić, 2015), addressing perceived usefulness and ease of use. Later, Venkatesh et al. (2003) extended TAM into a Unified Theory of Acceptance and Use of Technology (UTAUT) model, encompassing four determinants of intention and usage: performance expectancy, effort expectancy, social influence and facilitating conditions. The two models are often complemented by DeLone–McLean’s model for assessing information system success (DeLone and McLean, 2003), where the use (or intention to use) is a distinct dimension of information system success.

Many authors have proposed modified models, which include mainly variables derived from the above-mentioned models regarding the level of use (Venkatesh et al., 2003; Lean et al., 2009; Alomari, Woods and Sandhu, 2012; Shajari and Ismail, 2013). A growing number of papers that address smart city-related topics tackle the concepts of use and/or intention to use and explore the factors that can predict behavioural intention. Specifically, it has been confirmed that that (perceived) ease of use and usefulness affect the intention to use the applications in the (smart) city context (Althunibat, Alrawashdeh and Muhairat, 2014; Susanto, Diani and Hafidz, 2017; Buyle et al., 2018; Mensah, 2018). Perceived usefulness is the subjective probability that using the technology would improve the way a user could complete a given task (Jahangir and Begum, 2008) or the degree to which a person believes that using a particular digital service would enhance his or her performance (Davis, 1989). Furthermore, performance expectancy and effort expectancy (from the UTAUT model) are found to affect intentions to use services in smart cities positively (Gunawan, 2018; Habib, Alsmadi and Prybutok, 2019). A study exploring the intention to use digital coupons among university students (a population relevant to study at hand) showed, however, that perceived economic benefit (from DeLone–McLean’s model) has the most significant impact on intention to use (Guo, Li and Zheng, 2019). Although some authors have used the original TAM model and confirmed that usefulness and ease of use positively influence intention to use (Althunibat, Alrawashdeh and Muhairat, 2014; Mensah, 2018), the research gap has not been fully addressed (Rana et al., 2017).
Complementary View: Cost-Benefit Analysis

According to Salo et al. (2013), many studies confirmed that benefit (captured through perceived usefulness) is the most dominating factor to predict technology acceptance. Potential users of smart city services are more willing to use a digital service when they expect it will give them an obvious advantage or benefit over the alternative approach to those services (Tomitsch, 2018; Sepasgozar et al., 2019). Based on the growing interest and the focus on the benefits of using new services, the research study presented here aimed at providing a complementary and alternative view on the intention to use smart city services to standardly used acceptance models. A rationale for this approach is a recent observation that cities are still missing a universal approach to measuring factors affecting intention to use the citizen-oriented applications (Rana et al., 2017). The general purpose of digital services for citizens is to maximise benefits and minimise adoption barriers (Prybutok, Zhang and Ryan, 2008). However, users' benefits remain vague if they are not invited to assess them and critically evaluate the positives and negatives of using a specific digital service (Weerakkody et al., 2019). To showcase a standard method in a systematic approach to assessing benefits (positives) and costs (negatives) (Drèze and Stern, 1987) of smart city applications, the authors of the paper selected the Cost-Benefit Analysis (CBA) as a basis for further investigation of the factors influencing the intention to use. CBA is a generally applicable method that can provide a more comprehensive assessment in the smart city context (Masera et al., 2018).

Previous Work

Several studies from the perspective of end-users in the smart city domain have been published by the authors of this paper that are of relevance to this one and that this study builds upon. First, a subset of four priority smart city applications was selected based on user ratings of over 50 smart city applications published in (Ćukušić, Jadrić and Mijač, 2019). Specifically, associated costs and benefits of Smart parking, Water quality, Air quality and Public time tracking, reviewed in this paper, are amongst the top-rated applications having the highest priority in a local context. End-users were also invited to identify the perceived costs and benefits for each of the four selected smart city applications from their perspective and detect common costs and benefits for all four. The list of 98 different cost and benefit statements was generated, with 16 costs and 12 benefits common for all four applications (Jadrić, Mijač and Ćukušić, 2020).

At this stage and presented in this paper, based on the previous work, a research instrument is devised to detect which of the identified costs and benefits are considered the most important ones and which factors predict the intention to use the smart city applications. Factor analysis was used, and the linear regression model was developed to inspect and predict the intention to use the services. The results are presented herein.

RESEARCH METHODOLOGY

Research Procedure and Participants

The study at hand follows relevant guidelines for a mixed-methods approach (Creswell and Creswell, 2018), starting from a qualitative study followed by a quantitative one. Although the results from the first qualitative phase are reported in (Jadrić, Mijač and Ćukušić, 2020), for comprehensiveness, the procedure is described here as well, and the whole procedure is graphically presented in Figure 1.

The first phase began with the random separation of the participants into four groups in a dedicated workshop organised for the second-year students of the University in Split, Faculty of Economics, Business and Tourism. In preparation for a dedicated smart city workshop, a half-page description for each of the four selected smart city applications was prepared. All four applications were earlier identified as smart city priorities for the City of Split (Ćukušić, Jadrić and Mijač, 2019), where the study took place. Participants were then asked to generate a list of costs and benefits for the allocated...
application in a team exercise. Thus, each of the four groups was divided into eight teams, resulting in 32 teams in total. The time limit was set to 90 minutes, and the analysis following the CBA rules was performed in a controlled environment. All qualitative assessments were collected separately for each application, and afterwards, the statements were analysed to detect redundant and unique ones. The results were used to formulate the survey questionnaire; an instrument used in the second phase. It was prepared using an online tool Lime Survey. In addition to students that engaged in CBA activities, other students from the same year were invited to participate in the study. They were asked to access the link to the survey that was active over the course of five days. During that time, a total of 205 completed responses were collected, latter statistically analysed in SPSS. The participants are from a relatively homogeneous group, coming from the same age group, and sharing a similar educational and economic background. With regards to gender, almost 70% of the participants are female, consistent with the institutional enrolment data.

**Research Instrument for The Survey**

Based on the results from the analysis of CBA forms collected in the workshop (Jadrić, Mijač and Ćukušić, 2020), an online survey was prepared using the LimeSurvey tool and distributed in a controlled environment, in a computer lab and under authors’ supervision. From a generated list of statements concerning the costs and benefits of specific applications, only distinctive statements were used in the survey. In case there were repetitive, i.e. redundant statements, the ones that were formulated in the best way were left-in. As a follow-up, costs and benefits common to all four applications (smart
parking, water quality monitoring, real-time air quality information, and real-time public transit information) were identified. The intention was to explore the scenario where all four applications could be offered as a part of one integrated smart city solution. The total number of identified costs that could be considered as common for all smart city applications is 16. Fewer common benefits for the selected smart city applications from the end-users perspective were identified (a total of 12 statements). Apart from the common costs and benefits, several distinctive ones stemmed from the applications’ main purpose. The qualitative analysis resulted in a list of 98 different cost and benefit statements.

Participants were asked to estimate the intention to use for each application (smart parking, water quality, air quality, and real-time public transportation) within an integrated smart city solution. The seven-point scale was used (from 1 - I do not intend to use it at all, to 7 – I intend to use it all the time) following an example in (Vagias, 2006). The level of importance for all perceived benefits and costs was estimated (1 – not at all important; 7 – extremely important) using the list of 98 different cost and benefit statements. Finally, participants rated the usage frequency for mobile apps, public transport, car, and air and water quality reports (1 - never; 7 – all the time).

Data Analysis Methods

Standard methods were used for data analysis. First, the analysis of outliers and missing values were carried out along with the normality test. Although the values for skewness and kurtosis between -2 and +2 are considered acceptable to prove normal distribution by some accounts (George and Mallery, 2010), other, lower acceptable ranges for skewness and kurtosis below +1.5 and above -1.5 (Tabachnick and Fidell, 2013), and +1 to –1 (Hair et al., 2017) were endorsed to consider the distributions normal.

Following the recommendations from (Hair et al., 2010) that the factor analysis having the primary objective to define the structure between the variables is a good starting point before other multivariate analyses, the rotated component matrices were then prepared. Specific items were included in the structure of a factor if the difference in the factor cross-loadings is 0.2 or greater, and factor loading is a minimum 0.4. Another criterion was used whereby the factor with four or more item loadings greater than 0.6 was considered reliable (Field, 2009). Kaiser Meyer-Okin (KMO) Measure of Sampling Adequacy was used to determine appropriateness for conducting factor analysis, considering the values between 0.5 and 0.7 mediocre, between 0.7 and 0.8 good, between 0.8 and 0.9 great, and above 0.9 superb (Field, 2009). The ratio of participants to the number of statements was also considered. On one account the ratio of participants and variables of 5 to 1 is satisfactory (Hair et al., 2010), on another a sample size of 10-20 participants per variable is required for the exploratory factor analysis (Kline, 2015). However, a sample size of 200+ is acceptable.

Internal consistency as a standard measure of whether several items within the same construct produce similar scores (Cronbach, 1951) was calculated. As the most common, Cronbach’s alpha coefficient was reviewed against the following coefficient limits proposed by Kline (2015): 0.70/satisfactory, 0.80/very good, 0.90/excellent.

Correlation analysis was used for testing the relationship between the extracted factors of perceived benefits and costs of smart city applications and the intention of future use of such systems, i.e. the intention of using each application (smart parking, water quality monitoring, air quality monitoring and real-time traffic monitoring) as a part of an integrated smart city solution. Further, regression analysis (methods Stepwise and Enter) additionally determined relative contribution (independent relationship) for each explanatory variable by controlling the impact of other explanatory variables.

RESULTS OF THE STUDY

From the total number of 98 statements related to costs and benefits, first, the number of statements was reduced to a more appropriate one. Thus, only benefits rated with 6 (very important), and 7 (extremely
important) and costs rated with 5 (moderately important), 6 (very important), and 7 (extremely important) were taken into account for the instrument development. This approach resulted in an approximately similar number of benefits (18) and costs (15). The mean does not vary significantly between the selected items, ranging between 6.00 and 6.19 for benefits and 5.05 and 5.94 for costs. All distributions are normal, meeting the criterion of skewness or kurtosis below +1.5 and above -1.5.

The principal component analysis was then carried out with the 33 variables. As the number of respondents was N=205, the ratio of the number of respondents and variables meets the criterion 5:1 (Hair et al., 2010). KMO test (0.906) confirms sampling adequacy, and the model under the test fits the data, and Bartlett’s test of sphericity is statistically significant (Approx. Chi-Square=4141.539, df 528, Sig. .000). Based on Kaiser-Guttman’s criteria, the initial number of factors was seven, with the initial eigenvalue being 1 or above. These factors account for 66.954% of the total variance (Table 1). The first factor has an eigenvalue equal to 12.042 and accounts for 36.492% of the total variance, while the second factor with an eigenvalue of 3.564 accounts for an additional 10.799% of the total variance. The two factors account for 47.292% of the total variance.

Table 1. Total variance explained for the factor structure

| Component | Initial Eigenvalues | Extraction Sums of Squared Loadings | Rotation Sums of Squared Loadings |
|-----------|---------------------|------------------------------------|----------------------------------|
|           | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1         | 12.042 | 36.492 | 36.492 | 12.042 | 36.492 | 36.492 | 4.398 | 13.328 | 13.328 |
| 2         | 3.564  | 10.799 | 47.292 | 3.564  | 10.799 | 47.292 | 4.389 | 13.300 | 26.629 |
| 3         | 1.836  | 5.565  | 52.857 | 1.836  | 5.565  | 52.857 | 3.502 | 10.613 | 37.242 |
| 4         | 1.402  | 4.249  | 57.106 | 1.402  | 4.249  | 57.106 | 2.712 | 8.217  | 45.459 |
| 5         | 1.219  | 3.694  | 60.800 | 1.219  | 3.694  | 60.800 | 2.626 | 7.958  | 53.417 |
| 6         | 1.029  | 3.118  | 63.918 | 1.029  | 3.118  | 63.918 | 2.287 | 6.931  | 60.348 |
| 7         | 1.002  | 3.036  | 66.954 | 1.002  | 3.036  | 66.954 | 2.180 | 6.606  | 66.954 |
| 8         | .900   | 2.727  | 69.681 |        |         |         |        |        |        |
| ...       | ...    | ...    | ...    |        |         |         |        |        |        |

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 8 iterations.

The rotated component matrix is presented in Table 2. Rotated factor loadings lower than 0.4 are not presented, and variables with cross-loading on more than one factor with a difference lower than 0.20 are excluded from further analysis. Consequently, out of 33 items, 25 remain in the factor structure.

The extracted factors generally fit the measuring scales. The exceptions are “Smart parking benefits” were not all items are identified as a part of the same factor, and common costs are divided into two factors. Extracted factors are F1 – Smart parking benefits, F2 – Water quality monitoring benefits, F3 – Smart parking costs, F4 – Common benefits, F5 – Common costs (access to services and information), F6 – Water quality monitoring costs, F7 – Common costs (availability of devices and taxation).

Mean values (Table 3) do not vary significantly between factors, ranging from 5.1659 for F6 to 6.1285 for F4. The Intention to use has a slightly lower mean (4.6463), similar to the Use (4.6049). Skewness and kurtosis for all variables are within the ±1.5 interval. Internal consistency as a precondition for the instrument validity was checked against the standard range (by Kline, 2015),
### Table 2. Rotated component matrix for items measuring smart city app costs and benefits

| Questionnaire items                                                                 | Component |
|-------------------------------------------------------------------------------------|-----------|
| **SP-B-2 Use of application spares time and uncertainty when finding parking space.** | .815      |
| **SP-B-2 Use of application helps reduce traffic jams and crowds when looking for parking.** | .779      |
| **SP-B-3 Use the app reduces driver tension and stress caused by traffic jams and/or looking for parking.** | .715      |
| **SP-B-8 Application user can arrive at the nearest space using navigation.** | .603      |
| **SP-B-14 Application download is free and quick.** | .568      |
| **SP-B-9 In-application visuals allow users to view parking spaces for different groups of users, which can significantly assist people with disabilities.** | .528      |
| **SP-B-20 Application sends a warning to the user about the expiration of the paid parking.** | .454      |
| **WQ-B-13 Early intervention – after detecting contamination at the water source, if promptly reacted, further contamination can be prevented.** | .778      |
| **WQ-B-11 Preventing poisoning and contagion.** | .736      |
| **WQ-B-12 Raising awareness on water pollution.** | .733      |
| **WQ-B-16 Possibility of informing about drinking water when travelling to a destination.** | .694      |
| **AQ-B-11 Reducing carcinogenic effects on health.** | .688      |
| **RT-B-11 Estimating deviation for arrival and departure time based on historical data of previous routes.** | .481      |
| **RT-B-12 Real-time alerts for timetable changes.** | .421      |
| **SP-C-4 Using application while driving is contrary to traffic rules, and can result in a penalty.** | .739      |
| **SP-C-6 User can reach the parking space occupied in the meanwhile – resulting in the cost of time and fuel for use.** | .715      |
| **SP-C-1 In case of high demand, the price of parking spaces can increase.** | .712      |
| **SP-C-3 The risk of causing an accident and endangering others, due to using the application while driving.** | .705      |
| **SP-C-5 The high level of application usage potentially leads to an increase in the number of paid parking spaces, and at the same time in a decrease in free parking spaces.** | .672      |
| **CB-10 Mobile applications are easy to use.** | .813      |
| **CB-12 Information is presented in a user-friendly way.** | .713      |
| **CB-7 Information is available on devices I use every day.** | .412      |
| **CB-3 Update and transparent information are available on mobile phones 24/7.** | .438      |
| **CC-12 Occasional inability to use the application due to poor signal or using mobile data.** | .764      |
| **CC-5 Temporary unavailability of service in case of application/server overload.** | .618      |
| **CC-11 Spread of inaccurate information due to software bugs or sensor fault.** | .615      |
| **CC-10 Possibility of data misuse during application usage.** | .523      |
| **WQ-C-1 If it is disclosed that water is contaminated, it could have a negative impact on city/country reputation.** | .870      |
| **WQ-C-2 People’s mistrust can occur towards places with lower water quality.** | .841      |
| **RT-C-2 Location tracking has to be enabled.** | .608      |
| **CC-4 The cost of buying a new (mobile) device if the existing one is not compatible with the application.** | .759      |
| **CC-14 A potential threat of a virus related to the application could cause users to have their mobile device serviced.** | .651      |
| **CC-7 Greater country/city budget can reflect an increase in taxes or fees for citizens (users).** | .643      |

*SP – Smart parking, WQ – Water quality monitoring, AQ – Air quality monitoring, RT- Real-time public transit information, B- benefit, C – cost, CC – common cost, CB – common benefit*
whereby the extracted factors F4, F5, F6, and F7 and Intention to use, all have a good level, and F1, F2, and F3 have a very good level of internal consistency. The variable Use (of mobile applications, public transport, personal vehicle, water and air quality report access) does not have an acceptable level of internal consistency and is therefore excluded from further analysis of composite variables.

Table 3. Descriptive and Cronbach alpha for extracted factors, Intention to use, and Use

| Factors      | N  | Min | Max | Mean  | Std. Dev. | Skewness | Kurtosis | Alpha |
|--------------|----|-----|-----|-------|-----------|----------|----------|-------|
| F1           | 205| 2.67| 7.00| 6.117 | .99144    | -1.303   | 1.296    | .863  |
| F2           | 205| 2.80| 7.00| 6.064 | .93229    | -1.057   | .577     | .879  |
| F3           | 205| 2.20| 7.00| 5.822 | .96933    | -1.049   | .701     | .880  |
| F4           | 205| 3.67| 7.00| 6.128 | .78817    | -0.954   | .389     | .759  |
| F5           | 205| 2.00| 7.00| 5.252 | 1.16452   | -.364    | -.482    | .799  |
| F6           | 205| 1.00| 7.00| 5.165 | 1.49322   | -.846    | .390     | .781  |
| F7           | 205| 1.33| 7.00| 5.230 | 1.24057   | -.645    | .237     | .718  |
| Intention to use | 205| 1.50| 7.00| 4.646 | 1.17857   | -.083    | -.503    | .733  |
| Use          | 205| 2.50| 7.00| 4.604 | 0.81573   | .359     | .293     | .001  |

Since the variables are composite, more rigorous criteria for the normality test are taken into account with skewness and kurtosis in the ±1 interval (Hair et al., 2017). Consequently, nonparametric tests had to be performed: Spearman’s rho correlation coefficients are presented in table 4. Among the observed factors and the Intention to use the integrated smart city application, there is a weak but significant correlation.

Table 4. Spearman’s rho correlations between the factors and the Intention to use

|                  | Intention to use | F1    | F2    | F3    | F4    | F5    | F6    | F7    |
|------------------|------------------|-------|-------|-------|-------|-------|-------|-------|
| Intention to use | 1                | .359**| .427**| .372**| .268**| .218**| .163* | .252**|
| F1               |                  | 1     |       |       |       |       |       |       |
| F2               |                  | .520**| 1     |       |       |       |       |       |
| F3               |                  | .831**| .578**| 1     |       |       |       |       |
| F4               |                  | .439**| .525**| 1     |       |       |       |       |
| F5               |                  | .382**| .298**| .253**| 1     |       |       |       |
| F6               |                  | .179* | .311**| .197**| .428**| 1     |       |       |
| F7               |                  | .343**| .281**| .221**| .604**| .380**| 1     |       |

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Based on the results, the regression analysis was performed. The model tested if the extracted factors can significantly predict the Intention to use. The results, including the level of statistical significance, the standardised Beta coefficient, R, and R-squared, are presented in Table 5. For
regression analysis, both Enter (all independent variables are entered into the equation in one step) and Stepwise (include or remove one independent variable at each step) methods were used. Standard criteria were used for the probability of F (p-value) for the independent variable to be entered (0.05) or removed (0.01).

The results of the Stepwise method demonstrate that variable F2 Water quality monitoring benefits \((\beta = 0.250, p < .005)\) and F3 Smart parking costs \((\beta = 0.252, p < .005)\) significantly and positively predict the intention to use the four smart city applications within an integrated solution. The two predictor variables explain 20\% of the dependent variable variance. The results after using the Enter method show that only F2 Water quality monitoring benefits positively and statistically significantly predicts the intention to use the integrated smart city solution. This second regression model explains 22\% of the dependent variable variance. Significance tests for both regression models (p-value of the empirical F-ratio in the ANOVA table) indicate that both models are statistically significant. It is also important to note that the variable Use explains an additional 10\% of the variance, even though it is not internally consistent.

### Table 5. Stepwise and enter linear regression for dependent variable Intention to use

| Model                                      | Predictors | Stand. Beta | Sig. |
|--------------------------------------------|------------|-------------|------|
| Stepwise linear regression in 3rd step, \(R=0.452, R^2=0.204\) | F3         | .252        | .002 |
|                                            | F2         | .250        | .002 |
| Enter linear regression, \(R=0.464, R^2=0.216\) | F1         | .050        | .719 |
|                                            | F2         | .203        | .023 |
|                                            | F3         | .196        | .164 |
|                                            | F4         | .066        | .401 |
|                                            | F5         | -.027       | .744 |
|                                            | F6         | -.028       | .693 |
|                                            | F7         | .100        | .209 |

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**DISCUSSION**

To answer the first research question and expand smart city research from the users’ perspective (e.g. as in Lytras and Visvizi, 2021), results from CBA were used. A younger group of users and future users of smart city applications was asked to list all the costs and benefits for four specific applications from their perspective (Jadrić, Mijač and Ćukušić, 2020). The study results (in the form of survey statements) were subsequently used to develop an instrument. It proved to be a suitable framework, not only to gain insights into perceived costs and benefits for each of the selected smart city applications from users’ standpoint but also to identify common ones that could be used as a selling point for an integrated solution such as Split Smart City project (Split.hr, 2021). At the same time, the decision-makers may use the complete CBA method as a key tool for the relevant estimate of the suitability of the chosen solution or for its ex-ante pilot evaluation as proposed by Turečková and Nevima (2020). As a general framework, it was used to demonstrate that users perceive that the costs of using only one application are usually the same or at least similar to using many, whereas the benefits of using different applications vary greatly depending on their main purpose (Jadrić, Mijač and Ćukušić, 2020), i.e. they perceive a lot fewer costs than benefits. With the plans for introducing
new smart city solutions, this is encouraging for the local policy-makers in terms of predicting the adoption of a future (integrated) smart city solution.

By estimating the importance of the statements from their own perspective and based on the principal component analysis results, seven factors were identified. This approach provided more objective insight into what users perceive as the most important costs and benefits. Smart parking application yielded the most considerable number of benefits and costs in the first phase, and it was the second-highest-rated factor (F1) after common benefits (F4). The reason for a high awareness of the smart parking category and its perceived importance could be that in Split-Croatia (where most participants come from), there is a popular and well-promoted smart parking application. It could have affected the perceived benefits and intention to use in this regard.

Regression models were developed to identify variables that predict the Intention to use an integrated smart city solution comprising of the four selected applications, which provided an answer to second research question. Results show that F2 - Water quality monitoring benefits and F3 Smart parking costs, in particular, significantly and positively predicts the Intention to use the integrated smart city application. For water quality monitoring (and for smart parking) there was a bigger number of benefits identified than for two other applications. The importance of prompt alerts and reaction in cases of contamination, raising awareness on water pollution and reducing undesirable effects on individuals’ health, among other benefits, are all well-recognised by the group and affect the intention to use the application that would contain water quality monitoring functions. Again, this is relevant to the group of respondents considering the isolated water-related incidents in the wider Split area (Rogulj, 2017). The implication of this can be of major relevance for public administration managers in the City of Split as the incorporation of the water quality monitoring functions can increase the likeliness of usage intentions and the adoption of the integrated smart city application. Still, at the same time, it is not planned to be offered from the start (Split.hr, 2021). On a more general note, the perceived benefit influencing the intention to use the application is consistent with results from previous studies (Tomitsch, 2018; Sepasgozar et al., 2019). It is interesting to point out that costs (Smart parking) have a significant influence on intention to use, although mostly benefits (perceived usefulness) are considered to influence the intention to use (Tomitsch, 2018; Sepasgozar et al., 2019). Without approaching the topic from this perspective, it would be hard to identify this variable.

The study, along with the preliminary results (Jadrić, Mijač and Ćukušić, 2020), contribute to considerable research on the topic of evaluating the information systems from end-users perspectives. To date, the analysis of costs and benefits conducted from the perspective of (future) users of smart city applications has been under-researched, even though there are studies that advocate and source relevant information from users in smart cities for policy-making purposes (Lytras et al., 2021). Specifically, suppose the list of future smart city services is prioritised and based on the needs of the users, e.g. as in (Ćukušić, Jadrić and Mijač, 2019). In that case, an optimal set of services could be devised to minimise the costs for users of an integrated smart city application. In effect, a significant number of costs is common regardless of the functionality. Simultaneously, the benefits could be maximised as various (priority) functionalities could be bundled together and branded as part of an integrated smart city solution. Such a solution could ensure the vertical and horizontal integration of innovative smart city solutions (Frascella et al., 2018) and meet the expectations of stakeholders. In that regard, this study’s conclusion can contribute significantly to the specific context of Split – Croatia. For other urban environments, depending on the priorities, the costs would be expected to be comparable to the ones identified here, even though the benefits might vary considerably. Still, considering smart cities’ agenda is to increase the quality of life of its citizens, the list of future services is likely to include functionalities that contribute to the health and well-being agenda (Trencher and Karvonen, 2017; Forkan et al., 2019), as was the case in this particular study.

In addition to comprehensive CBA of smart city solution(s) from the perspective of investors and decision-makers (Turečková and Nevima, 2020), determining the costs and benefits from end-users side offers an integrative view, provides means for their comparison (Masera et al., 2018), and
CONCLUSION

Using CBA as a framework for further examination provides a more comprehensive assessment that can help understand users’ point of view. The study’s primary objective was to examine the end-users approach to evaluate the costs and benefits of smart city applications and explore the factors predicting the intention to use them. A quantitative approach was applied in this paper based on the qualitative CBA results, which uncovered the long list of perceived costs and benefits. It resulted in a better insight into the user perspective (seven factors were identified). Regression results showed that two factors (Water quality monitoring benefits and Smart parking costs) significantly impact the intention to use an integrated smart city solution, integration being here a crucial construct for smart city context as stated already. Results showed that the end-users approach can result in valued insight and should not be neglected.

The study has several limitations that impair the generalisation of the findings and call for further research. First, the participants are from a younger generation of (future) users. The effect of technology readiness and adoption readiness on millennials’ attitudes concerning services in smart cities has been noted (Singh and Mudang, 2020), finding that this generation is technologically better prepared to embrace such systems but needs further convincing about its benefits. While this study contributes to that regard, research that engages other age groups and inhomogeneous audiences is needed and planned in future stages. The effect of local factors on technology acceptance has also been confirmed (Sepasgozar et al., 2019). However, the relatively narrow geographical focus needs to be widened and addressed in future research studies, optimally through comparisons with cities in the wider region.

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