Smart City Mobile Apps Exploratory Data Analysis: Mauritius Case

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Abstract. Advances in technology are quickly paving the way for smart cities. According to Economic Development Board Mauritius, the Government of Mauritius has set up the Smart City Scheme to provide an enabling framework and a package of attractive fiscal and non-fiscal incentives to investors for the development of smart cities across the island. However, prior to the design and implementation of such technologies, it is important to predict the behavioural intention to use such technology so that smart city technologies effectively empower citizens and improve the quality of life of citizens. In this research work, it is proposed to use the Technology Acceptance Model (TAM) to effectively assess the perception and readiness and the perceived usefulness of certain smart city technologies such as for transportation as well as identifying key smart city applications for Mauritius. The aim of this research project is to evaluate and assess the different factors and condition that can have an impact on the perceived ease of use (PEOU), perceived usefulness (PU), attitudes towards using (ATT), behavioural intention (BI) to use and actual use (AU) of smart city technologies. This chapter is a complementary to the conference paper in SCA2019 which comprised Load Factor Analysis, here the focus is on Cronbach Alpha, Correlation and ANOVA.

Keywords: TAM · ANOVA · SmartCity App

1 Introduction

1.1 Rationale Behind the Citizen as a Major Stakeholder in Smart Cities

A Smart City encompasses an urban development vision that emphasizes the intelligent management of a city's resources for the purpose of solving urban challenges. This intelligent management almost always includes the participation of all the stakeholders of the city and not just the municipality itself. A vital prerequisite of this vision is the active participation and engagement of the most important stakeholder of all, the citizen. Courtesy: https://www.alliedtelesis.com/blog/ict-fundamental-enabler-smart-cities.

Smart cities are mushrooming around the Mauritius Island as depicted in Fig. 1. The Live-Work-Play model has been presented as socio economic development one. However, little has been done to evaluate or understand the citizen evolution in this new environment. This is simply due to the infancy stage of the smart cities on the Island. One aspect which is actually under consideration is about mobile intelligence.

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In other words when citizens would be roaming around in a smart city, what are the smart services available? Thus enforcing the concept of smart cities. The Smart City is for now the "Blind Men and the Elephant" parable, expectations and perception vary largely. The study presented in this chapter attempts to gauge the user acceptance of ICT based services for smart cities. As a matter of fact, in many cities across the globe for instance in the Taiwanese capital, the majority of the services are accessible via mobile apps. The methodology adopted is therefore a statistical analysis of a survey on smart city mobile apps.

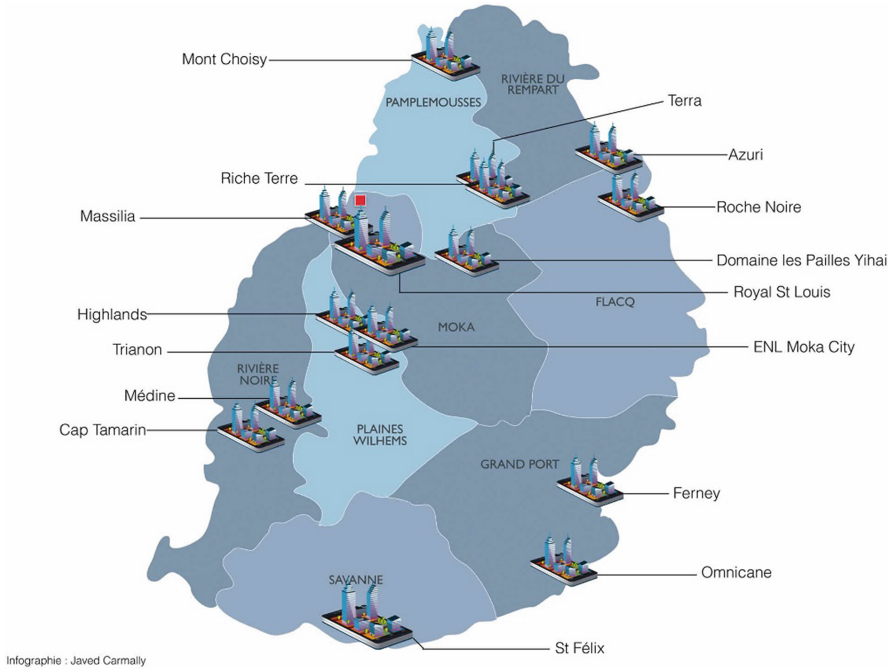

Fig. 1. 16 smart cities locations in Mauritius

1.2 Chapter Description

The rest of the chapter comprises a literature search described in Sect. 2 on the Technology Acceptance Model. Section 3 comprises the methodology including survey information and hypotheses. Exploratory data analysis is covered in Sect. 4 followed by conclusion in Sect. 5.

2 Technology Acceptance Model

Technology Acceptance Model is one of the most popular theory that is used widely to explain Information System usage. Many studies have been conducted which has led to the changes in the originally proposed model. A new model called combined TAM-TPB model which integrated the Technology acceptance model and theory of planned behaviour was proposed by Taylor and Todd [1]. Venkatesh and Davis [2] proposed a new version of TAM called TAM2 which added new variables to the existing model namely social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability). Venkatesh et al. [3] further proposed an improved model the Unified Theory of Acceptance and Use of Technology (UTAUT) Model.

The various studies conducted by researchers have tried to modify the TAM by adding new variables to it. Agarwal and Prasad [4] modified TAM by adding the construct of compatibility in the Technology Acceptance Model. Moon and Kim [5] has added a new variable playfulness factors to study acceptance of the World Wide Web. Chau [6] in a study reviewed TAM by included two types of perceived usefulness: near-term and long-term. Vander Heijden [7], after analysing the individual acceptance and usage of the website added two new constructs to TAM: perceived entertainment value and perceived presentation attractiveness. Chau and Hu [8] combined the factor of peer Influence with Technology Acceptance Model. Chau and Hu [9] further compared three models, namely the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and a decomposed TPB model that is potentially adequate in the targeted healthcare professional setting in Hong Kong. The results indicated that TAM was superior to TPB in explaining the physicians' intention to use telemedicine technology.

In [10], the authors examined the consumer acceptance of online banking using an extension of the TAM model where they reported that PU was more influential than PEOU in explaining technology acceptance. Similarly in [11], mobile banking adoption was studied using TAM and TPB.

In [12] an extended model based on TRA and TAM approach was used to predict acceptance of e-shopping. It was observed that PEOU and PU significantly determine individual attitudes toward e-shopping. This study also suggests that user acceptance is a better indicator of e-shopping intentions than user satisfaction. In [13], an extension of the TAM to include the four variables (process satisfaction, outcome satisfaction, expectations, and E-commerce use) was used to assess e-commerce where it was reported that the extended TAM explained actual behaviour in E-commerce environments better than the original TAM.

Scherer et al. [14] uses TAM to explain teachers' adoption of digital technology in education. It was concluded that using TAM is relevant but the role of certain key constructs and the importance of external variables contrast some existing beliefs about the TAM. Mobile learning (M-learning), which is based on learning activities using a mobile device like a smart phone, or tablet, is becoming increasingly important in today's networked environment.

The TAM model has been adopted to explain and predict the acceptance of M-learning [15], whereby the PU, PEOU, perceived enjoyment (PE) and the importance of perceived mobility value (PMV) i.e. the ability to learn anytime and anywhere were studied. The predictive power of the added constructs to TAM – PE and PMV – shows that the new variables were imperative. A general extended TAM for e-learning (GETAMEL) is proposed in [17] to include external factors namely Self-Efficacy, Subjective Norm, Enjoyment, Computer Anxiety and Experience. GETAMEL is further adopted to assess students' behavioral intention to use e-learning in Azerbaijan [21]. TAM has also be used in assessing user acceptance of Mobile Library Applications in Academic Libraries [18], where it was reported that PU, PEOU and interactivity and user satisfaction had significant effects on user attitude and intention to use mobile library applications. An extended TAM has also been used to evaluate user acceptance of YouTube for procedural learning [16]. This extended model took into consideration user satisfaction, content richness, vividness, and YouTube self-efficacy, as well as content richness, apart from PU and PEOU. In a study to understand the factors that influence the adoption of collaborative technologies (namely Google Applications for collaborative learning) to support team work in project-based environments, an enhance TAM is proposed [20]. The ability to share information in the collaborative learning environment was found to influence BI.

TAM has also been used to determine acceptance of Iranian agricultural consultants' of precision agriculture techniques and sustainable farming systems [22]. Similarly in [19], an application of the extended technology acceptance model (TAM2) was used to predict adoption of biological control for various types of pests among Iranian rice farmers. Other than PU, farmers' intentions of biological control were affected by perceived self-efficacy, facilitating conditions, and compatibility. However, PEOU was not considered as a positive factor towards BI.

3 Methodology

The quantitative method was selected for the study through the use of a questionnaire as it is a suitable way to reach a geographically dispersed audience at a relatively low cost. The survey which consisted some 16 pages was administered to a sample of 200 citizens of Mauritius. The convenience sampling method was used where citizens were approached online or through their work place. Respondents were rest-assured about the confidentiality and anonymity of the study.

The content validity of the questionnaire was confirmed by a panel of academic lecturers at the University of Technology Mauritius. The reliability of the questionnaire was estimated by conducting a pre-test in which 10 questionnaires were administered to respondents, who were then excluded from the sample. The response was quite spontaneous and the participants showed ease of understanding for the questionnaire. Following the pilot test, the questionnaire was slightly modified based on comments received from respondents.

The final questionnaire consisted of a short covering letter, and directions on how to fill the questionnaire. The first section of the questionnaire consists of 9 questions related to the profile of the citizen. The second section of the questionnaire consists of

21 questions based on the five features of the SmartCity App which was showcased to them through a video of the interaction with the app. The Smart City App is a collection of six different applications. These apps are Nearby Places app, Next Buses app, Weather Info app, Parking app, News app, and Complaint app.

The last section of the questionnaire consists of some 30 questions to assess the acceptance as well as to get input about the factors that may affect adoption such as quality of internet connection. Respondents were mainly asked to provide ratings on a 5-point Likert Scale for most questions, which was deemed convenient.

3.1 Sample Size and Hypotheses

The population size (the total number of people being studied) is 1, 263,820 at the end of 2016 [23] out of which 638,267 are women against 625,206 men. A sample of minimum 200 respondents is being targeted.

This section outlines the measurement scales used to build research constructs. Respondents were asked to indicate agreement with each statement in a measure using a five-point Likert-type scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree). The measures related to each construct then were assessed using respondent perceptions:

3.1.1 Perceived Usefulness (PU)

TAM posits that PU is a significant factor affecting acceptance of an information system. Davis defined PU as "the degree to which a person believes that using a particular system would enhance his or her job performance" [21]. Hence an application perceived to be more useful than another is more likely to be accepted by users. By applying these into the SmartCity App context we hypothesize:

Hypothesis 1. Perceived usefulness (PU) has a positive effect on consumer acceptance of the SmartCity App.

3.1.2 Perceived Ease of Use (PEOU)

According to TAM PEOU is a major factor that affects acceptance of information system [7]. PEOU is defined as "the degree to which a person believes that using a particular system would be free of effort". Therefore, the Smart City App if perceived to be easy to use is more likely to be accepted by users. Therefore, in this case, we hypothesize:

Hypothesis 2a. Perceived ease of use (PEOU) has a positive effect on consumer acceptance of the SmartCity App.

Hypothesis 2b. Perceived ease of use (PEOU) has a direct effect on perceived usefulness (PU).

3.1.3 User Satisfaction (US) and Perceived Enjoyment (PE)

Previous studies have indicated that User Satisfaction (US) affects the effectiveness of IS, system usage, as well as, directly or indirectly, affecting IS performance through IS usage. Although Davis did not include user information satisfaction in his TAM, we revised it based on prior studies and define it as user satisfaction with the

Internet/WWW. Regarding the use of the SmartCity App, this study is expected to derive the new relations among US, PU and PEOU.

Hypothesis 3a.User Satisfaction (US) has a positive effect on user acceptance of the SmartCity App.

Hypothesis 3b. PU positively affects User Satisfaction (US) of the Smart City App.

Perceived enjoyment refers to the extent to which the activity of using a computer is perceived to be enjoyable in its own right. This is contrasting to the PU, which be seen as an extrinsic motivation whereas perceived enjoyment (PE) as an intrinsic motivation to use information systems. A number of studies on PE have noticed that PE significantly affects intentions to use computers. Igbaria et al. [24] found that PE correlates positively with time of use but not with frequency of use or number of tasks. On this basis, we expect that PE affects the acceptance of the SmartCity App:

Hypothesis 4. Perceived enjoyment (PE) has a positive effect on user acceptance of the SmartCity App.

3.1.4 Behavioral Intention to Use (BI)

Behavioral Intention refers to the user's likelihood to engage in the use of the Smart City App. Therefore, in our research, it can be hypothesized:

Hypothesis 5a. Perceived ease of use (PEOU) has a direct effect on behavioural intention to use.

Hypothesis 5b. Perceived usefulness (PU) has a direct effect on behavioural intention to use.

3.1.5 Quality of Internet (QI)

The importance of a decent Internet connection and its quality was raised in our research. Without a proper Internet connection, the use of the Smart City App is not possible. Hence, we posit:

Hypothesis 6. The quality of the Internet connection has a positive effect on consumer acceptance of SmartCity App.

3.1.6 Citizen Experience and Readiness

We define Citizen Experience and readiness as the level of exposure of citizens to mobile applications. We believe that citizens who are used to consuming ICT services such as online shopping, e-banking, or communication will be more inclined to adopt the SmartCity App.

Hypothesis 7. Citizen Experience and Readiness has a positive effect on acceptance of SmartCity App.

4 Exploratory Data Analysis

4.1 Cronbach Alpha

Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. It is considered to be a measure of scale reliability. Used often in psychometric test.

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}} \quad (1)$$

Where N is the number of items,

$\bar{c}$ is the average covariance between item-pairs,
$\bar{v}$ is the average variance.

Cronbach Alpha was also carried out to test for the reliability of the factors obtained from Perceived Usefulness (PU), Perceived Ease of Use (PEOU), User Satisfaction (US), Personal Experience (PE), Behavioral Intention (BI) and Quality of Internet (QI). The results are shown in Table 1 as follows:

Table 1. Cronbach alpha results

Parameters	Cronbach alpha
PU	0.962
PEOU	0.772
US	0.947
PE	0.754
BI	0.970
QI	0.686

All of the above yielded values greater than 0.5, showing high reliability. Some authors prefer larger values of alpha, beyond 0.9 to characterize an excellent internal consistency.

4.2 Correlation

Table 2 shows the correlation between Perceived Usefulness, User Satisfaction, Behavioural Intention, Personal Experience and Quality of Internet. As expected, a very strong positive correlation (r = +807) was obtained between perceived usefulness and user satisfaction, indicating that the higher the user will perceive the SmartCity App to be useful, the greater he/she will be satisfied. Therefore, perceived usefulness predicts user satisfaction to a very great extent. Likewise, another very strong correlation (r = +.867) was observed between perceived usefulness and behavioural intention which means that, the greater the user will perceive the Smart App, the higher he/she will have the intention to use it again. However, a weak positive correlation (r = +.267) was observed between perceived usefulness and quality of internet indicating that perceived usefulness is less likely to predict the quality of internet. This implies that the extent to which the user will perceive the Smart App as being useful will less likely predict the quality of internet. Furthermore, a positive association between perceived ease of use and user satisfaction (r = +.743) was observed, which implies that the greater the user will perceive the App as being easy to use, the more likely he/she will be satisfied. Finally, a strong positive correlation (r = +.838) between user

satisfaction and behavioural intention was observed, which means that the greater the user will be satisfied, the more likely the user will have the intention to use it again. Hence, user satisfaction predicts behavioural intention very strongly.

The correlation coefficient is given by the formula below: (https://corporatefinanceinstitute.com/resources/knowledge/finance/correlation/)

$$r_{xy} = \frac{\sum (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum (x_i - \overline{x})^2 \sum (y_i - \overline{y})^2}} \quad (2)$$

$\mathbf{r_{xy}}$ is the correlation coefficient of the linear relationship between the variables x and y
$\mathbf{x_i}$ are the values of the x-variable in a sample
$\bar{\mathbf{x}}$ is the mean of the values of the x-variable
$\mathbf{y_i}$ are the values of the y-variable in a sample
$\bar{\mathbf{y}}$ is the mean of the values of the y-variable

Normally a correlation of 1 indicates a positive correlation of two items in the same direction, −1 in opposite direction and towards zero as a weak correlation. Also to mention that correlation does not necessarily imply causation. In this context a good QI does not imply good usage of adoption of services.

Table 2. Correlations between Perceived Usefulness, Perceived Ease of Use, User Satisfaction, Personal Experience, Behavioral Intention and Quality of Internet and their Means and Standard Deviations.

Measures	PU	PEOU	US	PE	BI	QI
PU	1					
PEOU	0.741**	1				
US	0.807**	0.743**	1			
PE	0.743**	0.592**	0.755**	1		
BI	0.867**	0.710**	0.838**	0.773**	1	
QI	0.267**	0.237*	0.352**	0.260**	0.372**	1

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

4.3 Anova

The Analysis Of Variance (ANOVA) is an important metric to study the impact of items within a group and impact among groups. Table 3 presents ANOVA results for age groups, whereas Table 4 across genders and Table 5 for educational levels. ANOVA compares the different samples means and we can use it for hypothesis testing too.

Table 3. Mean Scores (and standard deviations) for measured variables across different age groups

Variables	≤17	18–20	21–29	30–39	40–49	50–59	≥60	ANOVA
PU	–	4.16	3.62	3.62	3.11	3.88	4.00	F(1.172) = .329
	–	(.62)	(.97)	(.72)	(1.09)	(.29)	–	
PEOU	–	4.18	3.69	3.71	3.86	3.90	4.00	F(.464) = .802
	–	(.72)	(1.01)	(.75)	(1.20)	(.14)	–	
US	–	4.28	3.63	3.76	2.92	3.50	4.00	F(1.682) = .146
	–	(.57)	(1.02)	(.84)	(1.10)	(.71)	–	
PE	–	4.11	3.49	3.95	3.07	3.83	4.00	F(1.354) = .249
	–	(.83)	(1.05)	(1.27)	(1.16)	(.24)	–	
BI	–	4.15	3.57	3.71	2.82	3.88	4.13	F(1.616) = .163
	–	(.64)	(1.07)	(.83)	(1.10)	(.17)	–	
QI	–	3.74	2.81	2.98	2.21	2.56	2.88	F(1.153) = .338
	–	(3.62)	(.85)	(.85)	(1.10)	(.09)	–	

Table shows the F-test values, the F-test is computed as follows:

$$F - \text{test} = \text{variance of the group means} / \text{mean of the within group variances} \quad (3)$$

It is actually the ratio between the variation between sample means and the variation within the samples. In Table 3 the F-test values are closer to 0.5, for PEOU is around 0.8, which shows that the variance of the group means is higher compared to within the groups.

In Table 4, most of the F-test values seem normal except for the QI with an F-test score of 0.027 indicates a discrepancy between male and female citizens regarding the Quality of Internet. There is probably need to investigate into the Quality of Experience (QoE) although the latter is somehow linked to the Quality of Service (QoS) of the Internet connectivity.

Table 4. Mean Scores (and standard deviations) for measured variables across gender

Variables	Male	Female	ANOVA
PU	3.56	3.76	F(1.226) = .271
	(.93)	(.85)	
PEOU	3.79	3.72	F(.167) = .684
	(.91)	(.96)	
US	3.61	3.77	F(.686) = .409
	(.98)	(.95)	
PE	3.55	3.76	F(.823) = .366
	(1.06)	(1.18)	
BI	3.65	3.58	F(.105) = .746
	(.96)	(1.05)	
QI	3.15	2.55	F(5.021) = .027
	(1.57)	(.88)	

Table 5. Mean Scores (and standard deviations) for measured variables across different education levels

Variables	Primary	Secondary	Tertiary	ANOVA
PU	2.13	3.44	3.74	F(4.167) = .018
	(1.12)	(1.05)	(.80)	
PEOU	2.10	3.63	3.84	F(3.945) = .023
	(.14)	(1.22)	(.79)	
US	2.00	3.48	1.00	F(4.164) = .018
	(1.41)	(1.30)	(.27)	
PE	2.25	3.67	3.67	F(1.628) = .202
	(1.77)	(1.66)	(.85)	
BI	2.06	3.29	1.06	F(4.835) = .010
	(1.50)	(1.21)	(.25)	
QI	2.44	3.11	2.84	F(.474) = .624
	(1.33)	(2.31)	(.89)	

Table 5 shows the poor F-test values across the broad, it can be deduced from the gap between groups with primary educational level only and that of the tertiary one. Though it seems to be obvious, the table is a showcase of the risk of ICT digital divide in the context of smart cities.

5 Conclusion

As expected, a strong positive correlation was observed that the relationship between perceived usefulness and behavioural intention was strong. Therefore, the more users will perceive the Smart City Apps to be useful, the more they will have the intention of using it again. Furthermore, users will be more satisfied with the app if they find it more useful. This statement has been well supported by the results of this study which has shown a very strong positive correlation between perceived usefulness and user satisfaction. Lack of user acceptance is a significant impediment to the success of adoption of Smart City apps. The research has led to a Modified TAM model for Smart City apps. The concept of Smart City is quite subjective. Mauritius Citizens are mature users of Smart City mobile apps. Higher QI may not lead to higher Perceived Usefulness except for Real Time apps. There is need for popularization of smart city underlying technologies. Given the big number and openness of local Smart Cities, there is little risk of Digital Divide.

Following a seminar organised by the Mauritius Research Council (MRC) in the context of research findings dissemination, the following points shall be considered for future research. Much discussion was on the perception about smart city. Observations were exposed about improvement of utility services for cities be really smart and lack of motivations for promoters to invest into state of the art technologies. Debate was also held on the legal definition for smart cities in Mauritius. The sample of 200 to be broadened to represent a more realistic sample of the Mauritian population instead of

looking more at the millennials. More citizens are leaving towns to move to larger open space. One research question that would be interesting to explore is that, are there technological motives for people to move on to cities. Many governmental apps are underutilised. Request has been made to study the reasons behind. Acceptance should not be limited only to mobile apps but other ICT interfaces.

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