One-Stop Smart Urban Apps and Determinants of Their Continuance Usage: An Empirical Investigation Based on CSCM

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ABSTRACT

This study aimed to explore factors affecting continual usage of one-stop smart urban apps, which is the key to realise the vision of smart cities. A questionnaire (involved a total of 578 users/citizens) was carried out to test the research model, which was established based on existing user behavioural theories and recent literature on smart cities. The results, derived from confirmatory factor analysis and structural equation modelling, confirmed that lower costs (measured by cognitive effort and perceived risks), as well as higher “smartness” (measured by output usefulness, output velocity, and the quality of offline services), would lead to better user satisfaction. Moreover, system quality has indirect influence on user satisfaction (i.e., citizens only feel dissatisfied when system pitfalls affect output usefulness and output velocity of smart urban apps), which together with social influence will determine citizens’ continuance usage intention of smart urban apps.

KEYWORDS

Continuance Usage, Influential Factor, One-Stop Platform, Smart City, Smart Urban App

1. INTRODUCTION

It was warned by the United Nations that the world’s urban population is going to be nearly doubled from 3.4 billion in 2010 to 6.3 billion in 2050. Accompanied with this rapidly growing urban population, modern cities are confronted with various essential challenges, included but not limited to pollution, climate change, energy shortage, traffic congestion, and scarcity of education and healthcare resources (Peng et al., 2017; Bélissent, 2010). In order to deal with these increasingly severe city problems, governors in both developed (e.g. US, UK, and European nations) and developing (e.g. China, Mexico, and India) countries have invested heavily in smart city initiatives in recent years (Peng et al., 2017; Yeh, 2017). Townsend (2013) defined a smart city as a place seeking to embed advanced information and communication technologies (e.g. sensors, Internet of Things or IoT, cloud computing and big data analytics) with infrastructure, physical facilities, and everyday objects to “address social, economic and environmental problems” in the city. This can eventually lead to improving efficiency of city infrastructure, utilities and services, and also create a more sustainable and liveable environment for citizens (Neirotti et al., 2014; Lombardi et al., 2012).

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Owing to this global trend of smartness, dozens of smart apps with different functionalities and design purposes have emerged in cities and were made available to millions of urban citizens worldwide. For instance, smart parking apps can provide citizens with real-time information about parking availability detected by wireless sensors mined in parking lots (Peng et al., 2017). Smart bus apps can offer citizens with instant information about bus arrival times, bus locations and bus routes (Sharad et al., 2017). Smart clinical apps allow citizens to search for doctor availability in real-time, make medical appointments, receive online doctor consultations, and make payment for e-prescriptions (Wu, 2016). However, downloading and using these diverse smart apps may not always be convenient to citizens (Peng et al., 2019). Moreover, because these smart apps often run with totally different IT infrastructures and isolated datasets, their potential value may not be fully explored (Peng et al., 2019).

Consequently, there is an increasing trend for cities to integrate their hitherto isolated smart apps (and fragmented datasets) into a single platform, and developing so called smart urban apps. As depicted in Figure 1, a smart urban app is an integral part of the smart city ecosystem and has a set of essential features:

- It serves as the fundamental bridge to connect citizens with a city-wide network of IoT facilities (such as sensors in parking slots, buses, bins, and streetlights), as well as a range of city service providers (such as transportation bureaus, bus companies, public health departments, hospitals and medical centers, and energy suppliers). In other words, smart urban apps help to aggregate both online and offline resources of a city into a comprehensive local network
- With an integrated cloud data platform as the backbone, a smart urban app can serve as a unified and one-stop platform to offer citizens with various types of real-time information and smart city services, e.g. track real-time parking spaces/bus arrival times/air quality, make appointments to renew driving licenses, book medical appointments, receive online & offline doctor consultations, pay for energy bills, report a city violation, etc. (Peng et al., 2019).

Figure 1. Smart urban app at the core of smart city ecosystems

A recent study done by Peng et al. (2019) reported a total of 126 smart urban apps found across 140 smart cities in China. Similar one-stop smart initiatives were also found in New York City (i.e. NYC311 app, <https://www1.nyc.gov/311/index.page>) and Dubai (i.e. DubaiNow app, <https://dubainow.dubai.ae/en>), to name a few. When this increasing number of smart urban apps are emerging in city lives, many citizens would have gained their first-time experience of using such apps. However, anecdotal evidence shows that users' satisfaction rates may not always be high (Peng et al., 2017). The study done by Peng et al. (2017) further demonstrated that user satisfaction and continual usage of smart apps would determine the realization of intended economic and environmental benefits promised by smart city solutions in the long term. When previous research had explored factors affecting the adoption and usage of information technologies in different contexts, there seems to be a scarcity of studies targeting on continuance of smart urban apps. The study reported in this paper thus aims to fill this knowledge gap, by answering the research question: ***What determinants can influence continuance usage intention of smart urban apps?***

In order to answer this research question, the researchers proposed an integrated model (namely the Cost-Smartness Continuance Model or CSCM) by taking into account existing user behavioural theories and considering key features of smart urban apps. A questionnaire (involved a total of 578 users/citizens) was conducted, and the collected data was analyzed using confirmatory factor analysis and structural equation modeling. This study will be of interest and importance to city governors, service providers, IT practitioners and researchers who are engaged with smart city development worldwide.

2. OVERVIEW OF RELATED LITERATURE AND KNOWLEDGE GAP

The phenomenon of acceptance, adoption and usage of information technologies (IT) has been well studied since the 1980s, and has always been a prevalent research topic pursued in the information systems (IS) field (Venkatesh et al., 2003; Dağhan and Akkoyunlu, 2016). Researchers like Bhattacharjee (2001) argued that initial acceptance of a new information system is an important first step, but it does not guarantee continuance. That is, some users may discontinue IS use after accepting it initially, and so preventing the system from achieving long-term success.

The current situation of smart urban apps greatly echoed the arguments made by Bhattacharjee (2001). In fact, over the last few years, there have been an increasing number of urban citizens gained their first-time experience of downloading and using smart apps. However, user ratings of these apps as indicated in iOS and Android platforms have made researchers worried. For instance, it was reported by Peng et al. (2017) that a smart parking app in London only received a fairly low average rating of 1.97 (Min = 1; Max = 5). Another study done by Peng et al. (2019) reviewed 126 smart urban apps in China, and found that over 50% of these apps received a negative average score (i.e. below the medium rate of 3) from users. In light of the arguments made by Bhattacharjee (2001), such low satisfaction rates given by citizens would very likely trigger discontinuance of smart urban apps. A further review of the literature identified at least two important knowledge gaps related to this issue.

On one hand, there were very rich studies investigated continuance intention of information technologies in various contexts, such as mobile and e-commerce/learning/banking /governance (e.g. Bhattacharjee, 2001; Thong et al., 2006; Xu et al., 2013; Mouakket and Bettayeb, 2015; Tan et al., 2015; Oghuma et al., 2016; Dağhan and Akkoyunlu, 2016; Yeh, 2017; Weng et al., 2017; Veeramootoo et al., 2018). However, although existing continuance studies provide very useful insights for us to establish the research model (as presented below), none of them examined continuance intention of smart urban apps with consideration of the set of fundamental features discussed earlier.

On the other hand, there is a subset of emerging user behaviour research focused on smart city technologies and services (e.g. Marakhimov and Joo, 2016; Papa et al., 2018; Shin et al., 2018; Nascimento et al., 2018; Dehghani et al., 2018; Sepasgozar et al., 2019). Nonetheless, these studies

primarily investigated influencing factors of adoption intention and motivation to use, but did not provide any insight or explanation for complex continuous usage behaviours in post-adoption phase.

Therefore, there is an imperative need of research to understand factors/reasons influencing continual usage intention of smart urban apps, in order to realize smart city success in the long-term. The study reported in this paper is thus both timely and significant.

3. ESTABLISHING THE INTEGRATED COST-SMARTNESS CONTINUANCE MODEL (CSCM)

3.1. Overview of The CSCM Model

We started establishing the research model of this study by considering the cost-benefit rule. The cost-benefit rule is a basic principle used in behavioural economics and cognitive psychology to explain human actions (Morgan and Duncan, 1982; Larrick et al., 1993). It depicts that people's everyday decision about taking an action or not will be made based on cost-benefit reasoning: that is, an individual will take an action if (and only if) the benefit from taking the action is greater or at least equivalent to the cost incurred (Morgan and Duncan, 1982). In light of this reasoning, it is arguable that people will often be motivated by benefits gained from taking an action, whilst costs incurred from taking this action will have a discouraging psychological effect.

In this paper, we attempt to introduce the cost-benefit reasoning into the study of continuance of smart urban apps. We would argue that, after the initial adoption stage, citizens will assess the benefits and costs toward the usage of smart urban apps. In light of cost-benefit rules, both benefits and costs will have (either positive or negative) impacts on users' attitudes and satisfaction. In particular, the lower the costs and the higher the benefits which citizens experienced during their usage of smart urban apps, will lead to greater user satisfaction and so increase their continuance intention.

In terms of costs, we pay particular attention to effort required by citizens to use smart urban apps (i.e. cognitive effort), as well as potential risks (e.g. data and financial risks) that may occur. On the other hand, and considering the context of smart urban apps, we used "smartness" instead of "benefit". We proposed that smartness gained from smart urban apps would be associated with five dimensions, namely free of system pitfalls, output timeliness, output usefulness, and quality of online and offline services. Furthermore, and beyond personal usage experience, we considered that opinions of people surrounding a citizen would affect his or her continuance intention of smart urban apps (i.e. social influence). Finally, we incorporated a number of moderators (i.e. age, gender, education and income) into the model.

Overall, we developed an integrated model (Figure 2), namely the Cost-Smartness Continuance Model (CSCM), which contains 8 factors that may influence citizens' satisfaction and continuance intention towards smart urban apps with 12 hypotheses proposed.

3.2. Hypothesis Development

3.2.1. Costs: Cognitive Effort

Cognitive effort refers to time, energy and effort that citizens need to spend in using smart urban apps. Previous empirical research has demonstrated that the degree of ease of use is an important cognitive factor influencing users' view towards technology acceptance (e.g. Davis et al., 1989; Venkatesh et al., 2003) and post-acceptance satisfaction (Thong et al., 2006). In other words, when users feel it takes efforts (e.g. time and energy) to learn and use an information system, they may feel unpleasant (Kleijnen et al., 2007). Such negative feeling can offset the benefits gained from using the system and lead to user dissatisfaction (Swinyard, 1993). This can be particularly true for the usage of one-stop smart urban apps, which may often contain too many functions and services and so were complained to be complicated to learn, confusing to understand, and difficult to operate (Peng et al., 2019). If using such apps requires too much effort, users can become particularly frustrated (Kim et al., 2007).

Figure 2. The proposed Cost-Smartness Continuance Model (CSCM)

Thus, smart urban apps that require considerable user effort will cause negative effects and decrease user satisfaction. Therefore, the researchers proposed the following hypothesis:

H1. Cognitive effort negatively influences citizens' satisfaction of smart urban apps.

3.2.2. Costs: Perceived Risk

The second cost factor refers to perceived risk. Perceived risk is commonly considered as the uncertain feeling regarding the occurrence of an unexpected event that can lead to negative consequences or losses during the usage of information systems (Featherman and Pavlou, 2003; Peng and Nunes, 2009). In relation to Internet and mobile-based services, users are particularly concerned about whether their data is protected securely and treated confidentially by service providers (Kleijnen et al., 2007). Data privacy and security risks were thus regularly considered in IS acceptance and usage studies (e.g. Featherman and Pavlou, 2003; Kleijnen et al., 2007; Lin and Lu, 2015). In addition, Featherman and Pavlou (2003) highlighted other potential risks, including possible task performance related problems as well as uncertainty raised by Internet and wireless network communication issues, which can all potentially occur in the use of smart urban apps. IS researchers identified that perceived risk could create feelings of uncertainty, anxiety, and psychological discomfort toward IS usage (Dowling and Staelin, 1994; Featherman and Pavlou, 2003). Overall, it is reasonable to argue that citizens' concerns about unexpected risks and losses raised by the usage of smart urban apps will lead to anxiety and negative cognition toward these apps. Therefore, the researchers proposed the following hypothesis:

H2. Perceived risk negatively influences citizens' satisfaction of smart urban apps.

3.2.3. Smartness: Free of System Pitfalls

Previous empirical evidence shows that in order for an information system to be useful and deliver its intended benefits, the system should be of high quality (DeLone and McLean, 2003; Xu et al., 2013). Unfortunately, and in the context of smart cities, two recent studies done by Peng et al. (2017; 2019) identified that smart apps in UK and China were often complaint by users to have essential system quality issues and technical pitfalls (e.g. having over complicated and irrational system design, containing technical bugs that made apps freeze or even crash frequently, and lack of seamless data and system integration). In this study, the authors use the term "system pitfalls" to represent potential design deficiencies, functional shortcomings, technical bugs, data fragmentation, and other system quality issues that may affect the performance, efficiency and usability of smart urban apps. Various IS studies further confirmed that system quality issues would lead to user dissatisfaction (e.g. McKnight et al., 2002; DeLone & McLean, 2003; Chiu et al., 2007; Xu et al., 2013; Laumer et al., 2017; Veeramootoo et al., 2018). Overall, the researchers consider that free of system pitfalls is the first important dimension to measure smartness of smart urban apps, and proposed the following hypothesis:

H3. Smart urban apps that are free of system pitfalls are more likely to gain higher level of citizen satisfaction.

Moreover, Xu et al. (2013) propose that in the Internet environment, poor system quality can degrade the actual quality of information outputs and services that a web service system produces. The relationships among these variables were further supported by other IS researchers (e.g. Veeramootoo et al., 2018; Tan et al., 2013; Chang et al., 2012). The researchers would thus argue that system pitfalls of smart urban apps could affect the usefulness and velocity of information outputs as well as the quality of online services offered by these apps. Therefore, the following hypotheses were established:

H4. Smart urban apps that are free of system pitfalls are more likely to generate useful information outputs to citizens.

H5. Smart urban apps that are free of system pitfalls are more likely to generate timely and dynamic information outputs to citizens.

H6. Smart urban apps that are free of system pitfalls are more likely to deliver good quality online services to citizens.

3.2.4. Smartness: Output Usefulness and Velocity

DeLone and McLean (2003) depict that in the context of e-commerce, information quality refers to the quality of web content that "should be personalized, complete, relevant, easy to understand, and secure". The positive relationship between information quality and user satisfaction has been validated and confirmed in a number of studies (e.g. DeLone and McLean, 2003; Chiu et al., 2007; Xu et al., 2013; Daghan and Akkoyunlu, 2016; Laumer et al., 2017; Veeramootoo et al., 2018). In the context of smart cities, previous studies (e.g. Peng et al., 2017) also highlighted that smart apps should offer complete, relevant, accurate and personalized information and analytical outputs to meet and satisfy citizen needs. The researchers thus coined the second smartness factor of our model as "output usefulness" to capture these aspects. The concept of output usefulness contains two layers, namely basic information usefulness and analytical result usefulness. Basic information usefulness refers to whether smart urban apps are capable of providing users with complete, accurate and relevant basic information (e.g. locations of parking spaces or bus stops) when performing information seeking

tasks. On the other hand, analytical result usefulness refers to whether the analytical outputs (e.g. optimised traffic routes or disease prevention and alerts) generated by smart urban apps can meet personalized needs of citizens.

Moreover, and as introduced earlier, the smart city ecosystem involves the deployment of a city-wide network of IoT facilities, which will collect a range of real-time data in the city (e.g. parking availability, air quality, trash level of bins). Through one-stop smart urban apps, local citizens can get access to this full set of real-time, instant and dynamic data and information, and so make their city lives smarter and more convenient (Peng et al., 2019). The authors thus coined “output velocity”, which refers to whether smart urban apps can provide users with timely, instant and dynamic data and information, as the third smartness factor to reflect this essential real-time feature embedded in smart urban apps. Consequently, the following hypothesis was proposed:

H7. Output usefulness can positively influence citizens’ satisfaction of smart urban apps.

H8. Output velocity can positively influence citizens’ satisfaction of smart urban apps.

3.2.5. Smartness: Online and Offline Service Quality

Service quality is an important construct proved by many IS researchers to have significant influence on user satisfaction and long-term IS success (DeLone and McLean, 2003; Chiu et al., 2007; Kim et al., 2011; Xu et al., 2013; Nunkoo et al., 2017; Veeramootoo et al., 2018). For smart cities, researchers in the field highlight that the whole endeavor of smart city development aims to provide high quality on-demand city services to citizens and so improve their city lives (Lombardi et al., 2012; Neirotti et al., 2014; Peng et al., 2017). In this context, smart urban apps serve as the intermediate between city service providers and citizens. As exemplified at the beginning of this paper, local citizens can obtain dozens of services, according to their demand and actual requirements, from multiple service providers, through the window of one-stop smart urban apps (e.g. over 50 different city services can be obtained through DubaiNow app, <https://dubainow.dubai.ae/en>). It is important to note that, some of these city services are delivered online and represent some of the key functions of smart urban apps (e.g. online doctor consultations, e-payments for energy bills/parking fees/traffic fines/e-prescriptions). Apart from these, smart urban apps can also serve as the gateway for citizens to book and receive offline services from related city service providers (e.g. offline medical consultations, visa interviews, passport/driving license/trade license application submission). It is apparent that the quality of services obtained offline is pretty much depending on the actual service providers, rather than on the quality of smart urban apps. However, empirical studies (e.g. Peng et al., 2019) show that if citizens are not happy with the offline services received, their frustrated feeling may often be extended to the usage of smart urban apps. Given these considerations and empirical evidence, the follow hypothesis was proposed:

H9. Online service quality positively influences citizens’ satisfaction towards smart urban apps.

H10. Offline service quality positively influences citizens’ satisfaction towards smart urban apps.

3.2.6. Satisfaction, Social Influence and Continuance Intention

Bhattacharjee’s (2001) proposed that, user’s continuance intention of an information system is largely based on his or her satisfaction with prior system usage. A large number of IS studies (e.g. Xu et al., 2013; Tan et al., 2013; Lin and Lu, 2015; Dağhan and Akkoyunlu, 2016; Veeramootoo et al., 2018) has also validated a strong and close relationship between user satisfaction and continuance intention. The following hypothesis was thus established:

H11. User satisfaction positively influences citizen’s continuance intention of smart urban apps.

Further to personal experience and satisfaction, a user's intention toward using an IS can also be influenced by the normative views of close friends and family members surrounding him/her (Venkatesh et al., 2003; Weng et al., 2017). The strong impact of social influence on IS usage has been validated by a number of studies (e.g. Ajzen, 1991; Venkatesh et al., 2003; Hsu and Lu, 2004; Weng et al., 2017). It can thus be deduced that citizens may be more intend to continue the usage of a smart urban app when their friends and family members also support and recommend them to do so. Therefore, the following hypothesis was proposed:

H12. Social influence is positively related to citizen's continuance intention of smart urban apps.

3.2.7. Control Variables

It is widely demonstrated in previous research that users of different ages, genders, education levels and income levels may have dissimilar perceptions and attitudes towards IS acceptance and usage (Venkatesh et al., 2003; Lin and Lu, 2015). This study thus adopts these four additional control variables to test the proposed research model. The researchers particularly attempt to explore whether the influence of the cost-related constructs, smartness-related constructs, and social influence on satisfaction and usage of smart urban apps would be moderated by age, gender, education and income.

4. METHODOLOGY

4.1 Questionnaire Survey

Questionnaire-based surveys are common tools in testing research models and hypotheses in deductive studies (Wu, 2009). For this study, a questionnaire was developed to identify and validate factors influencing usage of smart urban apps. The questionnaire mainly contained 5-point Likert-scale items (ranging from 'strongly disagree' to 'strongly agree') to investigate factors listed in Figure 1, which were thought to influence continuance of smart urban apps. The actual constructs/factors and items designed in the survey, together with definitions and sources are presented in Table 1. Moreover, demographic information (i.e. age, gender, income and education) of respondents was also collected at the end of the survey. Please note that, the questionnaire was initially developed in English as the constructs and items were grounded from English literature. It was then carefully translated into Chinese by the research team, of which the members are bilingual in both languages. This translated questionnaire was then tested with 20 local citizens. Based on pilot testing, the questionnaire was revised, i.e. four items were reworded and typographical errors were removed.

4.2 Data Collection Process

It is widely acknowledge that China has invested very heavily in its national smart city initiative in recent years. From 2012 to 2017, over 700 smart city projects across more than 500 cities had been initiated and launched jointly by central and local governments. A recent study done by Peng et al. (2019) further identified a total of 126 smart urban apps in over 140 Chinese cities. In light of this national background, the city of Guangzhou has always been a pioneer in the smart city journey. In fact, Guangzhou is the political, economic and cultural center of South China. It covers a total area of 7,434.4 square kilometers, with over 14 million population and annual GDP of 2.3 trillions RMB (over US\$340 billions) in 2018. The local government launched a one-stop smart urban app (called *Guangzhou Tong*, literally Guangzhou Pass) in 2015. According to a domestic mobile data mining and analysis tool (called Qimai, <https://www.qimai.cn/>), the number of downloads for this app exceeded 2 million by the time of this research. Guangzhou was thus selected as a suitable city to carry out the empirical stage of this study.

In order to better explain the concept of smart urban apps as well as the purpose of the study to Chinese citizens in Guangzhou, the research team made a particular effort to carry out the survey

Table 1. Questionnaire constructs and sources

Construct	Definition	Items	Sources
Cognitive effort (CE)	To what extent citizens perceive that the usage of smart urban apps will consume their effort	CE1: I feel it costly to learn and use smart urban apps;	Lin and Lu (2015)
		CE2: It takes my time and energy to develop new skills and knowledge to use smart urban apps;	
		CE3: Smart urban apps are complicated to understand and use.	
Perceived risk (PR)	To what extent citizens perceive that the usage of smart urban apps involves risks	PR1: I worry that my data in smart urban apps may not be protected securely and confidentially;	Featherman and Pavlou (2003); Weng et al. (2017)
		PR2: I feel insecure and risky to use functions and services offered by smart urban apps;	
		PR3: I think the usage of smart urban can involve various unexpected risks.	
Free of system pitfalls (FoSP)	Smart urban apps run logically and reliably and are free of technical bugs	FoSP1: I feel smart urban apps have clear and rational system design;	Dağhan and Akkoyunlu (2016); Xu et al. (2013)
		FoSP 2: I feel smart urban apps are reliable and will not freeze up or get crashed easily;	
		FoSP 3: Smart urban apps don't have technical bugs or system pitfalls.	
Output usefulness (OU)	Information and analytical outputs provided by smart urban apps are accurate and useful to meet citizen needs	OU1: Information and analytical outputs provided by smart urban apps are useful and reliable;	Dağhan and Akkoyunlu (2016); Xu et al. (2013)
		OU2: I feel information shown in smart urban app has high level of accuracy;	
		OU3: Smart urban apps can always provide reliable and accurate analytical results to meet my needs.	
Output velocity (OV)	Smart urban apps provide real-time, instant and dynamic information to citizens	OV1: Various types of real-time information provided by smart urban apps are updated speedily;	Dağhan and Akkoyunlu (2016); Xu et al. (2013)
		OV2: I feel the real-time information shown in smart urban app are properly updated;	
		OV3: Smart urban apps can always provide real-time and dynamic information that I need.	
Online service quality (OnSQ)	Citizens can gain good-quality online services through smart urban apps	OnSQ1: Online services obtained through smart urban apps make my city life more convenient;	Dağhan and Akkoyunlu (2016); Xu et al. (2013)
		OnSQ2: Smart urban apps can provide me with good quality online services;	
		OnSQ3: Online services obtained through smart urban apps help me to resolve city problems effectively.	
Offline service quality (OffSQ)	Citizens can gain good-quality offline services through smart urban apps	OffSQ1: Smart urban apps can connect me with relevant service providers, from whom I can receive good offline services;	Dağhan and Akkoyunlu (2016); Xu et al. (2013)
		OffSQ2: I am happy with the offline services obtained through smart urban apps;	
		OffSQ3: I can obtained good quality offline services through smart urban apps.	
Social influence (SI)	To what extent citizens' opinions towards smart urban apps are affected by others surrounding them	SI1: People that I know have good impression about smart urban apps;	Venkatesh et al. (2003)
		SI2: When I talk to family members about smart urban apps, they usually give positive comments;	
		SI3: People around me support the usage of smart urban apps.	
Satisfaction (SA)	To what extent citizens are satisfied with their experience of using smart urban apps	SA1: I am fully satisfied with my experience of using smart urban apps; SA2: I am happy with the usage of smart urban apps; SA3: I have positive experience towards using smart urban apps.	Bhattacharjee (2001)
Continuance Intention (CI)	Citizen's continuance usage intention of smart urban apps	CI1: I fully support and recommend the daily usage of smart urban apps; CI2: I am willing to continue the usage of smart urban apps on a regular basis; CI3: I intend to use smart urban apps continuously in my daily life.	Bhattacharjee (2001)

in person. During the time of data collection, three research assistants of the team visited different residential and commercial areas in the city. Local citizens were approached randomly and were given a brief introduction of the study, but only those who were interested in the topic and confirmed that they had experience in using the Guangzhou Pass app were invited to join the survey. To address the concern that citizens may not have time or may be unwilling to fill in the survey on the street, the researchers developed an online version of the questionnaire. The URL of the online survey was given to potential respondents who expressed a willingness to help with the questionnaire but did not want to fill it in immediately. In total, 4126 local citizens in Guangzhou were approached and 578 responded to the survey, representing a response rate of 14%. Amongst the respondents, 512 citizens filled in the questionnaire in person, and 66 completed it online. A demographical profile of these respondents is given in Table 2, and the results and findings from this study are presented in the following section.

Table 2. Sample demographics (N = 578)

Measure	Items	Frequency	%
Gender	Male	268	46.37
	Female	310	53.63
Age	£ 18	63	10.90
	19-24	180	31.14
	25-34	213	36.85
	35-44	60	10.38
	45-54	39	6.75
	55-64	18	3.11
	³ 65	5	0.87
Education level	High school and below	125	21.63
	Bachelor degree	342	59.17
	Postgraduate degree	111	19.20
Monthly income (Chinese RMB)	£ 5000	277	47.92
	5001-10000	192	33.22
	10001-20000	83	14.36
	20001-30000	11	1.90
	³ 30001	15	2.60

5. DATA ANALYSIS AND RESULTS

The questionnaire data collected was handled and analysed by following the two-step structural equation modelling process proposed by Anderson and Gerbing (1988): firstly, a confirmatory factor analysis was performed to test reliability and validity of the measurement model; secondly, the structural model with hypotheses associated with the defined factors was tested.

5.1. Testing The Measurement Model

A confirmatory factor analysis on the measurement model was performed in IBM SPSS in order to confirm whether the collected data has sufficient reliability and validity. In particular, reliability and convergent validity were measured by Cronbach's alpha together with composite reliability (CR) and average variance extracted (AVE), as shown in Table 3. During this process, one item respectively from Satisfaction (SA) and Continuance Intention (CI) was removed from the analysis, because these items had factor loadings below 0.5 (Mojtahed et al., 2014) and so would affect item reliability of the measurement scales (Lewis-Beck, 1994). Consequently, the Cronbach's alpha of all constructs exceeded the recommended value of 0.7 (Kaplan and Saccuzzo, 2008). The CR estimates were all above 0.75 (higher than the suggested value of 0.7), and all of the AVEs exceeded the acceptable value of 0.5 (Lin and Lu, 2015). These results indicate that all constructs have reliability and convergent validity. In addition, the authors use the Haman single-factor test to evaluate the common method bias. The result shows that the variance interpretation percentage of the first common factor is 47.129%, which does not exceed the critical value of 50% (Podsakoff and Organ, 1986; Hair et al, 1998). Furthermore, in order to determine discriminant validity, the authors compared the squared correlations (i.e. shared variances) between constructs with the square roots of AVEs for individual constructs. As the rule-of-thumb, the later should be greater than the former (Fornell and Larcker, 1981). Table 4 shows that the AVEs were all higher than the shared variances, demonstrating good discriminant validity.

In addition, to ensure that the measurement scales have no multicollinearity, Variance-Inflation Factor (VIF) was performed. The results showed that the VIF values for all factors in the model are less than 10. These results met the recommended values given by Hair et al. (1998), and so indicate that multicollinearity problem is not likely to exist. Moreover, and prior to testing the hypotheses, the researchers assessed the overall Goodness-of-fit of the measurement model, by computing χ^2/df ($=2.674$), goodness of fit index or GFI ($=0.922$), adjusted goodness of fit index or AGFI ($=0.81$), normed fit index or NFI ($=0.831$), comparative fit index or CFI ($=0.931$), and root mean square error of approximation or RMSEA ($=0.054$). All of these model-fit indices (also shown in Table 5) met the values suggested by previous researchers (e.g. Lin and Lu, 2015; Mojtahed et al., 2014; Scott, 1994; Hair et al., 1998; Bagozzi and Yi, 1988), thus demonstrating that the measurement model obtained an adequate model fit.

5.2. Testing The Structural Model

The structural model was tested by using AMOS 22.0. From Table 5, the structural model also showed a good model fit ($\chi^2/df=2.728$, GFI=0.89, AGFI=0.861, NFI=0.914, CFI=0.943, RMSEA=0.057). Subsequently, the hypotheses associated with the defined factors were tested. Table 6 presents the standardized path coefficients, path significances, standard errors, and explained variance (R^2). It was confirmed and validated that citizens' experience and satisfaction of using smart urban apps could be negatively affected by cognitive effort ($\beta = -0.254$, $p<0.001$) and perceived risk ($\beta = -0.163$, $p<0.001$), and be positively influenced by output usefulness ($\beta = 0.385$, $p<0.01$), output velocity ($\beta = 0.548$, $p<0.001$), and offline service quality ($\beta = 0.192$, $p<0.01$), with an explained variance (R^2) of 94%. These results validated Hypotheses 1, 2, 7, 8 and 10 respectively. However, since no statistically significant relationships were found for "free of system pitfalls", "online service quality" and "user satisfaction", Hypotheses 3 and 9 were not supported. Meanwhile, it was validated that smart urban apps with less system pitfalls would have positive impacts on output usefulness ($\beta = 0.946$, $p<0.001$), output velocity ($\beta = 0.879$, $p<0.001$) and online service quality ($\beta = 0.957$, $p<0.001$). In other words, Hypotheses 4, 5 and 6 were supported. Finally, user satisfaction ($\beta = 0.734$, $p<0.001$), together with social influence ($\beta = 0.178$, $p<0.05$), can then significantly influence continuance usage intention of smart urban apps, with an explanatory power (R^2) of 80%. As such, both Hypotheses 11 and 12 were supported and confirmed.

Table 3. Descriptive statistics and convergent validity

Constructs	Items	Factor loadings	Mean	SD	Cronbach's alpha	CR	AVE
Cognitive effort (CE)	CE1	0.767	3.383	0.897	0.797	0.799	0.571
	CE2	0.691	3.189	0.942			
	CE3	0.804	3.220	0.894			
Perceived risk (PR)	PR1	0.620	2.227	0.864	0.768	0.765	0.522
	PR2	0.742	2.402	0.788			
	PR3	0.796	2.642	0.835			
Free of system pitfalls (FoSP)	FoSP1	0.820	3.681	0.735	0.803	0.795	0.566
	FoSP2	0.687	3.578	0.804			
	FoSP3	0.743	3.615	0.736			
Output Usefulness (OU)	OU1	0.761	3.910	0.730	0.837	0.837	0.632
	OU2	0.815	3.824	0.735			
	OU3	0.808	3.906	0.682			
Output Velocity (OV)	OV1	0.705	3.897	0.796	0.799	0.799	0.570
	OV2	0.765	3.908	0.814			
	OV3	0.793	3.812	0.762			
Online service quality (OnSQ)	OnSQ1	0.798	3.735	0.701	0.840	0.841	0.638
	OnSQ2	0.814	3.724	0.672			
	OnSQ3	0.783	3.694	0.735			
Offline service quality (OffSQ)	OffSQ1	0.711	3.942	0.745	0.765	0.776	0.541
	OffSQ2	0.620	3.846	0.817			
	OffSQ3	0.856	3.820	0.681			
Social influence (SI)	SI1	0.743	3.861	0.715	0.799	0.801	0.573
	SI2	0.797	3.752	0.740			
	SI3	0.729	3.675	0.769			
Satisfaction (SA)	SA1	0.871	3.921	0.678	0.837	0.838	0.721
	SA2	0.827	3.929	0.693			
Continuance intention (CI)	CI2	0.899	4.047	0.666	0.842	0.845	0.732
	CI3	0.810	4.038	0.698			

This study also explored whether the influence of CE, PR, OU, OV, OffSQ and SI on satisfaction and continuance intention of smart urban apps would be moderated by age, gender, education and income. The results showed that after the moderators incorporated, the standardized path coefficients for the hypotheses changed relatively but related path significances had not much difference. Spearman's correlation test was then applied as a further layer of analysis. The results also did not return any significant findings, except the relationship between education and perceived risk. In particular, it was found that citizens with higher education levels were more concerned with potential risks associated with continuance usage of smart city apps ($r = 0.351$, $p < 0.001$). The researchers thus concluded that the moderators did not have major influential effect in general (and so were removed

Table 4. Discriminant validity

Construct	CE	PR	FoSP	OU	OV	OnSQ	OffSQ	SI	SA	CI
CE	<i>0.76</i>									
PR	-0.59	<i>0.72</i>								
FoSP	0.50	-0.45	<i>0.75</i>							
OU	0.33	-0.44	0.71	<i>0.79</i>						
OV	0.36	-0.41	0.62	0.70	<i>0.75</i>					
OnSQ	0.46	-0.43	0.71	0.77	0.70	<i>0.80</i>				
OffSQ	0.39	-0.44	0.59	0.71	0.57	0.65	<i>0.74</i>			
SI	0.41	-0.44	0.70	0.74	0.69	0.73	0.67	<i>0.76</i>		
SA	0.30	-0.44	0.62	0.75	0.75	0.70	0.65	0.74	<i>0.85</i>	
CI	0.26	-0.38	0.55	0.70	0.67	0.67	0.60	0.70	0.77	<i>0.86</i>

Note: Off-diagonal elements are shared variances; diagonal elements (italic) are square roots of AVEs; for discriminant validity, diagonals should be greater than off-diagonals.

Table 5. Goodness of fit measures

Statistics	Recommended values	Measurement model	Structural model
χ^2 (df)	-	871.820	878.462
$\chi^2/(\text{df})$	<3	2.674	2.728
Degree of freedom	-	307	322
Goodness-of-fit index (GFI)	> 0.90	0.922	0.890
Adjusted goodness-of-fit index (AGFI)	> 0.80	0.810	0.861
Root mean square error of approximation (RMSEA)	< 0.08	0.054	0.057
Normed fit index (NFI)	> 0.80	0.831	0.914
Comparative fit index (CFI)	> 0.90	0.931	0.943

from the empirical model shown in Figure 3), but the impact of education on perceived risk during smart urban app usage in the long term should be given adequate attention.

6. DISCUSSION AND IMPLICATIONS

6.1. Further Discussion

Consistent with prior studies (e.g. Bhattacharjee, 2001; Thong et al., 2006; Xu et al., 2013; Dağhan and Akkoyunlu, 2016; Veeramootoo et al., 2018), the results of our research confirm that user satisfaction is a key determinant of continuance intention, even for smart urban apps. Moreover, previous studies (e.g. Featherman and Pavlou, 2003; Kim et al., 2007; Kleijnen et al., 2007; Lin and Lu, 2015) have

Table 6. Hypothesis testing in the structural model

Hypothesis	Path	Standardized coefficient (β)	Standard error	Results
H1	CE@SA	-0.254***	0.038	Supported
H2	PR@SA	-0.163***	0.046	Supported
H3	FoSP@SA	-0.059	0.332	Not supported
H4	FoSP@OU	0.946***	0.065	Supported
H5	FoSP@OV	0.879***	0.069	Supported
H6	FoSP@OnSQ	0.957***	0.066	Supported
H7	OU@SA	0.385**	0.124	Supported
H8	OV@SA	0.548***	0.098	Supported
H9	OnSQ@SA	-0.007	0.191	Not supported
H10	OffSQ@SA	0.192**	0.069	Supported
H11	SA@CI	0.734***	0.092	Supported
H12	SI@CI	0.178*	0.099	Supported
Constructs		R ²		
Satisfaction (SA)		0.940		
Continuance Intention (CI)		0.799		
Notes: ***p<0.001; **p<0.01; *p<0.05				

Figure 3. Final model confirmed by SEM analysis

shown and this study confirms the negative impacts of cognitive effort and perceived risks on user satisfaction. Further to personal experience and satisfaction, this study supports prior continuance research (e.g. Ajzen, 1991; Venkatesh et al., 2003; Hsu and Lu, 2004; Weng et al., 2017) and confirms that social influence can strongly affect continuance intention of smart urban apps.

However, a rather surprising result is that free of system pitfalls has no direct influence on user satisfaction towards smart urban apps. This finding contradicts prior studies, which often highlight that system quality is an important and direct determinant of IS success and usage (e.g. DeLone and McLean, 2003; Chiu et al., 2007; Xu et al., 2013; Nunkoo et al., 2017; Veeramootoo et al., 2018). A possible explanation is that, smart urban apps have nowadays penetrated into the everyday life of Chinese citizens, who are more concerned with the usefulness and timeliness of various types of real-time information obtained from the app (i.e. both constructs were confirmed to have significant influence on user satisfaction). As such, citizens become more tolerant of system pitfalls and deficiencies of smart urban apps, as far as the app can provide them with useful, accurate and real-time information they need. In this context, system quality has indirect influence on user satisfaction (i.e. citizens only feel dissatisfied when system pitfalls and deficiencies affect output usefulness and output velocity of smart urban apps), as confirmed in the findings.

Further to real-time information, citizens can also obtain a range of online and offline services through smart urban apps. However, our findings contradict again previous studies (e.g. Xu et al., 2013; Dağhan and Akkoyunlu, 2016; Veeramootoo et al., 2018) and show no statistically significant relationship between online service quality and user satisfaction. Nonetheless, and beyond the conventional online environment, our study confirms that user satisfaction can be affected by the experience of offline services obtained through smart urban apps. These findings actually make sense, considering the current development of smart city apps in China as reported by Liang et al. (2019). In particular, after reviewing and analysing 333 local smart city apps, Liang et al. (2019) concluded that the development of one-stop smart urban apps was still in an early stage. As such, these apps serve more as the gateway for citizens to book and receive offline services from various service providers (e.g. health organisations, transportation departments, city councils, and energy companies), without the capacity of providing more advanced and personalised online services based on big data analytics and artificial intelligence technologies (Liang et al., 2019). Consequently, citizens may not have much expectations and concerns on the online services currently available, and their satisfaction and feelings are more affected by the quality of offline services obtained through smart urban apps.

6.2. Theoretical Implications

The results of this study have made some important theoretical contributions to the literature on both IS continuance usage and smart city development. This is one of the few studies that investigated smart city with an IS perspective (Peng et al., 2017), and is certainly an early (if not the only) attempt to explore continuance intention of one-stop smart urban apps using user behavioural theories. Researchers (e.g. Bhattacharjee, 2001; Thong et al., 2006; Xu et al., 2013; Mouakket and Bettayeb, 2015; Tan et al., 2015; Oghuma et al., 2016; Dağhan and Akkoyunlu, 2016; Veeramootoo et al., 2018) had investigated continuance intention of IS in various settings (such as e-commerce, e-learning, mobile banking, and mobile governance, to name a few), but have not paid much attention to the context of smart urban apps. This study established and validated the CSCM model, which was grounded based on previous theories and specific features of smart urban apps. It also introduced the cost-benefit rule into IS continuance research. When many proposed hypotheses were confirmed and validated, the results showed indirect (rather than direct) correlations between system quality and user satisfaction. This finding is very different from existing theories and results reported in prior research, but makes sense in the context of smart urban apps as discussed above. Another unexpected result is that, the quality of online services has no significant influence on user satisfaction, but the quality of city services obtained offline can significantly affect citizens' feeling and satisfaction towards smart urban apps. Overall, the results of this study constitute a theoretical improvement for IS continuance theory.

This study provides a good theoretical basis and starting point for future continuance research in the increasingly important context of smart urban apps.

6.3. Practical Implications and Recommendations

From a practical perspective, the ultimate aim of an IS continuance research is to facilitate long-term organizational success through effective and continuous IS usage (Veeramootoo et al., 2018). In essence, this study aims to make the same practical contribution, that is, to facilitate the realization of smart city visions by ensuring continuance usage and viability of one-stop smart urban apps. This study has provided an understanding of the key factors affecting continuance usage intention of such urban apps.

More specifically, empirical evidence shows that many current one-stop smart urban apps may be embedded with too many functions and services, which can make the system interface over complicated and difficult to understand (Peng et al., 2019). Our study reinforces that user satisfaction can be negatively affected by time, energy and efforts required for citizens to learn and use smart urban apps. As such, app developers should attempt to design and develop more simplified, flexible and personalized user interface to make sure citizens can understand and use these apps easily (e.g. allowing citizens to customize the interface by selecting and keeping specific functions and services that they truly need, rather than merely putting everything all in one place). Adequate demo functions and information pages, which can pop up after initial launch of the app, will bring in extra convenience and help users capture main functions of the system more easily and quickly.

Furthermore, it is confirmed that user satisfaction of smart urban apps can be negatively influenced by potential data privacy and security risks that may occurred. As highlighted by previous researchers (e.g. Dutta et al., 2013), in order to prevent the occurrence of these risks, city governors cannot just reply on technical solutions. More rigorous data protection regulations will need to be established, to make sure that the large volume of citizen data captured through smart urban apps will not be misused or accessed by unauthorized parties (Dutta et al., 2013). In light of this, our results also indicate that, city governors need to pay more attention to users with higher education levels, as this group of user was found in this study to be particularly aware of and concerned with data-related risks.

On the other hand, this study confirms that user satisfaction can be enhanced by improving the usefulness and timeliness of information outputs of smart urban apps. To achieve this, city governors cannot merely rely on app developers, especially considering the fact that smart urban apps are not standalone applications but an integral part of the smart city ecosystem. As such, it is fundamental to deploy firstly a comprehensive network of IoT facilities in the city. This city-wide network of IoT facilities can so collect a full range of real-time data, which then need to be properly integrated, processed and analysed in the centralised cloud platform. Beyond the online environment, citizens can book and receive a wide range of offline city services through smart urban apps. The study confirms that the quality of services obtained offline from service providers can also affect user satisfaction, which can then influence users' continuance intention of using smart urban apps. In fact, city service providers may sometimes see smart urban apps as a fashionable tool to improve their service and public image. But it should be argued that, although smart urban apps provide a new channel for service providers to communicate and interact with citizens, they are not panacea to resolve all service quality issues. City service providers should attempt to raise their service efficiency and quality by providing more training to staff and improving existing operational settings.

Overall, these results clearly indicate that smart urban apps cannot be simply treated as a standalone piece of mobile application. City governors, IoT suppliers, app developers, and service providers need to work collaboratively with careful strategic planning and monitoring to deliver the best possible real-time information and city services to citizens through one-stop smart urban apps. It is essential to offer not just good individual usage experience but also a healthy and supportive usage atmosphere in the general public, to facilitate continual citizen usage of such one-stop smart platforms in the long run.

6.4. Limitations and Future Studies

While this study makes considerable contributions to current theory and practice, the authors also recognize its limitations, especially related to the sample of respondents. In particular, only stakeholders with prior experience of using smart urban apps were invited to join the survey. The resulted sample is thus relatively unbalanced in certain demographical aspects. Most notably, the vast majority (i.e. close to 80%) of the respondents/users fell into the age groups between 19 and 44, and only about 10% of the respondents aged 45 or above (with less than 1% of users aged 65 or above). Nonetheless, the 2013 Oxford Internet Survey report shows that, people at retired ages always lag behind, and people at education and employment life-stages are more regular users of Internet and mobile applications, i.e. nearly all students (92%) and most employed people (74%) were found to be “next generation users” who routinely access the Internet from multiple locations and devices (Dutton et al., 2013). In other words, our sample possibly reflects the actual age structure of smart urban app users. Another issue in the sample is that it was drawn only from Chinese citizens in the city of Guangzhou. Therefore, the generalizability of related findings may be limited.

Given these sampling limitations and the current scarcity of user behavioral study on smart urban apps, further research in this area is strongly recommended. Future studies can reuse the CSCM model as the theoretical foundation, and test and validate the model in other Asian and even Western countries/cities, where smart city is currently a part of the national development strategy. Apart from continuance intention, it will be meaningful to explore in the future factors affecting the acceptance of smart urban apps among the ageing population, with the aim of better advocating these one-stop smart mobile tools to the older population.

7. CONCLUSION

One-stop smart urban apps lie in the core of smart city ecosystems, and serve as the means to connect a city-wide network of IoT facilities and service providers with millions of local citizens. In this context, continual usage of such smart apps will determine the success and realisation of smart city visions in the long-term. To the best of our knowledge, the topic of continuance intention of smart urban apps had not been much studied in the current literature. To address this knowledge gap, this study proposed and validated the CSCM model, which synthesized constructs from the current literature and applied the cost-benefit reasoning in the context of smart urban apps. The results confirmed that lower costs (in terms of lower cognitive effort and lower perceived risk), as well as higher smartness (indicated by output usefulness, output velocity, and the quality of offline services), would lead to higher user satisfaction, which was also indirectly affected by system quality. Personal experience and satisfaction, together with social influence, will then determine citizens' continuance usage intention of smart urban apps. This study does not just contribute to IS continuance theory but can also be useful for smart city deployment and strategic planning. As such, this study will be of interest and value to IS and smart city researchers, as well as city governors and practitioners in this area.

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