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Towards people-centric smart city development: Investigating the citizens' preferences and perceptions about smart-city services in Taiwan

Abstract

City administrators hoping to achieve people-centric smart city (SC) development require a clear understanding of citizens' preferences and perceptions about SC services. This study fills that need by presenting evidence-based research on such preferences and perceptions from the perspective of *need theories*, taking Taiwan as a case study. Specifically, we investigated Taiwanese citizens' preferences for 35 SC services of seven dimensions classified in two domains, as well as their three perceptions of the usefulness of these SC services in the realization of human needs. The results show that most of our respondents clearly perceived SC services as both important and useful to their existence, relatedness, and growth needs, and that they expressed relatively higher preferences for such services to operate in the "hard" domain – e.g., smart energy, smart transport, or smart safety –than the "soft" one, e.g., smart living. Based on these findings, this study provides policy recommendations that, if implemented, could be expected to advance SC development by increasing citizens' usage of SC services in both the hard and soft domains, and serve the wider aim of improving their well-being and quality of life.

Keywords: Citizens' preference; City development; Human needs; People-centric; Smart-city services.

1. Introduction

Cities across the world are facing a lot of urbanization challenges. Since 2018, more than 55% of the world's population has been living in cities, and this figure is expected to climb to 70 percent by 2050 (United Nations, 2018a). As the 21st century's dominant form of civilization, cities are the powerhouses of economic growth and at the forefront of innovation, thereby attracting more and more people (Muggah & Barber, 2016; United Nations, 2020). However, the rapidity of urbanization has also meant that cities are both causes and victims of various environmental problems. As compared to all other types of settlements, they are the world largest resource consumers and pollution creators, responsible for more than 60% of resource use and 70% of global carbon emissions (United Nations, 2020). Additionally, due to their high concentrations of people and property, cities are uniquely vulnerable to unprecedentedly strong and frequent natural disasters, driven or exacerbated by climate change (Macke et al., 2018). Other severe environmental and social problems that are particularly marked in cities include biodiversity loss, ecosystem destruction, regional disparities and socioeconomic inequity (Yigitcanlar et al., 2019). As such, city governments are disproportionately responsible for tackling these challenges, but must find ways of balancing sustainability and resilience measures with economic prosperity and innovation.

Amid rapid advancement in information and communication technologies (ICT), many international countries or cities are increasingly recognizing the role of smart city (SC) development in mitigating urbanization issues (Caragliu et al., 2011; Fernandez-Anez et al., 2018). In 2015, the U.S administration announced a new "Smart Cities" Initiative for investing over 160 million U.S. dollars in federal research, aiming to help local

communities tackle their urbanization challenges such as traffic congestion and climate-change effects (The White House, 2015). In 2017, the Hong Kong government published a *Hong Kong Smart City Blueprint*, where a set of SC initiatives and pilot projects were proposed for solving city challenges such as population aging and resource scarcity (ITB, 2017). Other SC development plans in global countries or cities include Singapore's Smart Nation Initiative (Ho, 2017), Japan's Kitakyushu smart community project (Chatfield & Reddick, 2016), and Amsterdam's Smart City program (Carlo Francesco, 2016). Under the global SC development, different dimensions of SC services have been provided in cities for covering all aspects of local citizens' urban life, e.g. Vienna's six dimensions of SC services – smart governance, smart economy, smart environment, smart mobility, smart people, and smart living (Fernandez-Anez et al., 2018). Although global cities have different endowments on SC development and SC services provision, one common theme of SC development has been widely acknowledged: SC development should be people-centric, serving the needs of local citizens with the wider aim of improving their well-being and quality of life (Caragliu et al., 2011; Neirotti et al., 2014; Capdevila & Zarlenga, 2015; Yeh, 2017; Fernandez-Anez et al., 2018; Macke et al., 2018).

People-centric SC development requires the global governments to see things through the eyes of the public, specifically, to provide the SC services that meet the needs[1] and preferences[2] of the citizens. On the one hand, despite the fact that the citizens are key stakeholders in every phase of SC development, their actual needs are often not well considered in SC projects' top-down implementation (Bouzguenda et al., 2019; Nicolas

[1] Need is something which people believe they lack and ought to have, e.g., the citizens' usage of SC services for satisfying their physical and psychological needs.

[2] Preference is the selection of something over others, e.g., the citizens may prefer some specific types of SC services over other types.

et al., 2020; Porumbescu et al., 2020; Wu, 2020). For example, researchers from Switzerland and Singapore conducted a massive survey among the citizens of 102 cities for assessing their perceptions[3] of the SC projects made available to them (Bris, 2019). The results found that in Paris, after a local public bike-sharing project was implemented for five years to alleviate congestion and reduce pollution, the local citizens perceived this bike-sharing project as useless because they believed that air pollution was not a problem in Paris. Similar situations also happened in many other international cities (e.g., Shanghai, Tokyo, and Tel Aviv) that the citizens did not feel their needs were well satisfied from local governments' massive investment of advanced smart technologies (Bris, 2019). On the other hand, given limited government budget, city administrators are often needed to set priorities for a wide range of SC services for optimizing the allocation of resources (CPU, 2015). To avoid the massive investment of SC projects do not meet the citizens' needs and expectations, it is essential for city administrators to better understand local citizens' preferences for SC services, which can help to inform their decision-making on investment priorities and resource allocation for SC services that are urgently needed by the citizens (Lin et al., 2019). However, in current academic community, most empirical studies mainly focus on the discussion of the benefits of SC services for citizens (Macke et al., 2018; Lin et al., 2019) and the factors affecting the citizens' usage of SC services (Belanche et al., 2016; Yeh, 2017), while there is generally a lack of empirical studies especially focusing on the citizens' needs and preferences about SC services.

In response to this research gap, the current study aims to explore the citizens'

[3] Perception is the organization, identification, and interpretation of sensory information for understanding the presented information or environment, e.g., the citizens may have different perceptions of the usefulness of SC services made available for them.

preferences about SC services and their perceptions of the usefulness of such services to the realization of human needs. Specifically, it will seek detailed answers to the following research questions:

1. What are citizens' preferences regarding SC services, and do such preferences vary significantly across the designated 35 SC services of seven dimensions within two domains (i.e., hard and soft)?

2. What are citizens' perceptions of the usefulness of SC services to the realization of their human needs, and do such perceptions vary significantly across their demographic characteristics?

Taiwan is a particularly rich case for a study of this kind. It is one of the most urbanized places in the world, with a 78.5% urban population (United Nations, 2018b). Moreover, during the past two decades, its central government has proposed a series of SC initiatives to promote smartness in urban development, including Electronic Taiwan in 2002, Mobile Taiwan in 2005, Ubiquitous Taiwan in 2007, Intelligent Taiwan in 2009, Wireless Taiwan in 2010, Digital Taiwan in 2012, and Smart Taiwan in 2017 (Arinto & Akhtar, 2009; Yen et al., 2011; Chou & Hsu, 2017). By taking advantage of new ICT developments, these SC services initiatives have effectively leveraged Taiwan's strengths in economic development and urban sustainability. Following these central-government steps, municipal governments in Taiwan have implemented numerous SC solutions in different domains (some examples of which are listed in **Table A.1**). International SC bodies including the Smart City Summit & Expo and Intelligent Community Forum (ICF) have recognized Taiwan's cities' remarkable achievements in SC development. For example, Taipei City and Taichung City won the ICF's global "Intelligent Community of the Year" SC award in 2006 and 2013, respectively

(Taiwantoday, 2017). Nevertheless, the Taiwan Industrial Technology Research Institute has highlighted the critical importance to future SC development of resolving local urban-development challenges from a more citizen-oriented perspective (Su, 2017). It is hoped that the present investigation will help Taiwanese and other governments shape future SC development in ways that meet citizens' needs and preferences and improve their well-being and quality of life.

2. Literature review

2.1 The definition of SC and SC services

Amid rapid advancement in ICT, the concept of SC has risen to prominence in the sphere of urban planning, due to its presumed or actual efficacy at mitigating a range of issues arising from rapid urbanization. This term was first proposed in the 1990s, as part of a discourse on how new ICT might be used to modernize urban infrastructure (Albino et al., 2015), but it has various historical predecessors – including *intelligent*, *digital*, *virtual*, *ubiquitous*, and *knowledge* cities – reflecting ICT advancements over time (Lee & Lee, 2014). The definition of SC has been evolutionarily enriched in two perspectives: "technological means" and "desired ends". On one hand, technology corporations have often defined SC from the technological-means perspective; for example, IBM defined an SC as "an instrumented, interconnected, and intelligent city" (Harrison et al., 2010). Specifically, the term "instrumented" in that definition refers to a capability for data collection using various sensors; "interconnected" means a capability for data integration by using a powerful computing platform; and, "intelligent" refers to a capability for data analysis, optimization, and visualization in the service of better decision-making. Academics in the urban-planning field, in contrast, have tended to focus on desired ends – notably, citizens' needs – when designing SC services, with

the wider aim of improving well-being and quality of life (Caragliu et al., 2011; Neirotti et al., 2014; Capdevila & Zarlenga, 2015; Yeh, 2017; Macke et al., 2018). For example, Caragliu et al. (2011) argued that "a city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and high quality of life" (p.70). Similarly, Neirotti et al. (2014) deemed SC services to be successful only if they provide citizens with an improved way of living.

To develop people-centric SC, city administrators must provide citizens with a wide range of SC services. Such services can be broadly defined as any ICT-based urban services that serve citizens' day-to-day needs (Lee & Lee, 2014). As such, they can be further subdivided into "hard" and "soft" domains (Neirotti et al., 2014). The former refers to the SC services where ICT systems play decisive roles in the functions of tangible urban infrastructure, including buildings, energy grids, natural resources, water and waste management, transport, and logistics. The soft domain, in contrast, refers to SC services where ICT systems play auxiliary roles in less-tangible urban processes such as education, culture, entrepreneurship policies, innovation, social inclusion, and citizen engagement/e-government.

SC services can also be broken down into several subdomains (hereafter, "dimensions") based on other typological frameworks (Lee & Lee, 2014). Examples include Giffinger and Gudrun (2010) six dimensions – smart economy, people, governance, mobility, environment, and living – and Jeong et al. (2009) 10 dimensions, i.e., smart administration; transportation; public health, medical care, and welfare; environment; crime and disaster prevention; facilities management; education; culture, tourism, and sports; distribution; and work and employment. However, because there is no one

dominant typological framework for classifying SC services (Lee & Lee, 2014; Albino et al., 2015), such classification usually is undertaken on the basis of municipal governments' administrative convenience, and thus varies widely across local contexts.

2.2 Citizens' perspectives on SC services

The importance of municipalities' SC service provision being people-centric has been widely acknowledged in the academic community. A considerable body of literature has emphasized that using SC services can contribute to citizens' well-being and quality of life (Macke et al., 2018; Camboim et al., 2019; Ismagilova et al., 2019) and contribute to urban areas' social, economic, and environmental sustainability (Bibri & Krogstie, 2017; Shen et al., 2018; Yigitcanlar et al., 2019). Due to SC services' presumed and actual benefits to citizens, an increasing number of empirical studies have sought to capture citizens' perspectives on such services (**Table A.2**). Some studies have empirically investigated how specific characteristics of SC services may influence people's well-being or quality of life. For example, Macke et al. (2018)'s case study of the city of Curitiba, Brazil revealed that its citizens' quality of life could be improved via SC services in the spheres of socio-structural relations, environmental well-being, material well-being, and community integration. Of course, it is not always possible to draw a hard line between perceptions and actual improvement: as in Lin et al. (2019)'s survey of Chinese SCs, which found that residents' experiences of SC services as safe, useful, and convenient positively affected their subjective senses of well-being.

Several other empirical studies have investigated factors affecting the uptake of SC services, or the usage of other urban services in SC contexts. For example, Belanche et al. (2016)'s case study of the city of Zaragoza, Spain found that its citizens' education levels, possession of smart user cards, and positive attitudes towards SCs appeared to

boost their overall usage of urban services. Yeh (2017)'s subsequent survey of cities in Taiwan revealed that acceptance of SC services was affected by people's beliefs about innovation; their self-reported personal innovativeness; and their perceptions of privacy, trust, and SC service quality. Collectively, these studies highlight the usefulness of SC services, and identify several key factors that could contribute to their acceptance.

2.3 Citizens' needs and preferences about SC services

Capturing and analyzing citizens' motivations for using SC services could help drive up rates of acceptance of specific SC services or service dimensions. Human needs are the driving forces of human behaviors, and this has given rise to *need theories* of human behaviors and motivations (Arnolds & Boshoff, 2002; Yang et al., 2011; Caulton, 2012). However, as indicated in **Table A.2**, studies that discuss SC services from a need-theory perspective are especially rare. The handful of exceptions include the work of Xu and Geng (2019) and Kwon and Kim (2007). Adopting Alderfer's (1969)'s existence, relatedness and growth (ERG) theory, Kwon and Kim (2007) regrouped the ubiquitous smart services offered by various ubiquitous-city projects in South Korea, and found that citizens' existence needs were overemphasized, and their relatedness and growth needs were underemphasized. By adopting the Maslow (1958)'s need-hierarchy theory, Xu and Geng (2019) created a framework for characterizing SC research and applications that they called people-centric service intelligence. That framework highlighted that the use of ICT in SCs should be derived from and comply with citizens' demand for support of their physiological, safety, love, esteem, and self-actualization needs. However, no empirical verifications of such claims have hitherto been published.

If they are to achieve high rates of local acceptance of SC services, it is also necessary for city administrators to understand citizens' preferences about those services. Yet,

despite the fact that they are key stakeholders in every phase of SC development, citizens often are treated as peripheral to SC projects' top-down implementation (Bouzguenda et al., 2019; Nicolas et al., 2020; Porumbescu et al., 2020; Wu, 2020). Amid rapid advancements in ICT, usage of SC services has become a norm rather than an exception in urban life (Lee & Lee, 2014). Thus, it is timely to seek empirical evidence about citizens' preferences regarding SC services – in particular, because such evidence could increase awareness of the role of citizens in driving smartness in city management (Vidiasova & Cronemberger, 2020); help increase the uptake of SC services by tailoring such services to citizens' expectations (Boll et al., 2014); improve the efficiency of SC service delivery, thus aiding governments' strategic positioning of SCs (Cuadrado-Ballesteros et al., 2013; Belanche et al., 2016); and provide indications of where new investment in SC services is urgently needed (Lin et al., 2019). All of these outcomes would facilitate the emergence of SC strategies that are cost-effective, people-centric, and locality-specific. However, despite these benefits, empirical studies focusing on citizens' SC service preferences remain relatively scarce (Pereira et al., 2018; Cronemberger & Gil-Garcia, 2019; Vidiasova & Cronemberger, 2020), which is also reflected in **Table A.2**.

3. Methodology

As shown in **Fig. 1**, the present study's investigation of Taiwanese citizens' preferences and perceptions about SC services consists of three stages: questionnaire design, data collection, and analysis methods. Each stage is described in detail in the following subsections.

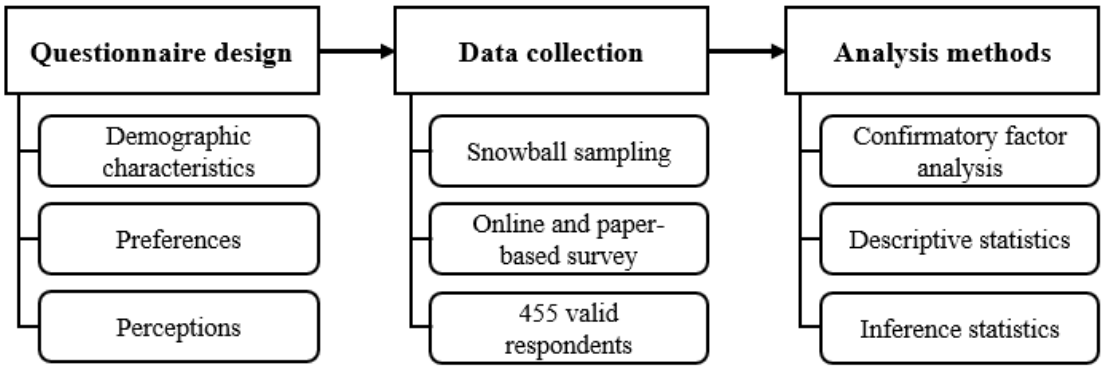

Fig. 1. The methodology flowchart of the present study.

3.1 Questionnaire design

As shown in **Table A.3**, we designed a questionnaire to investigate Taiwanese citizens' preferences and perceptions about SC services, consisting of three parts. The first part included five questions on the respondents' demographic characteristics, including gender, age, place of current residence, educational attainment, and occupation. The second part comprised 35 questions covering the respondents' preferences about seven dimensions of SC services, including smart energy (four questions), smart environment (six), smart people (six), smart living (seven), smart transport (four), smart safety (four), and smart health (four). These seven dimensions were drawn from both peer-reviewed and grey SC literature (Lee & Lee, 2014; Neirotti et al., 2014; Chen, 2017; Chou & Hsu, 2017; Institute for Information Industry, 2017; Fernandez-Anez et al., 2018). Among these dimensions, smart people and smart living represent the soft domain, and the others, the hard domain.

The third part of our questionnaire contained three questions on the respondents' perceptions of the usefulness of SC services to the realization of their human needs,

based on Alderfer (1969)'s ERG theory. This theoretical framework was chosen because it has been extensively validated in the fields of psychology and organizational behavior (Robbins & Judge, 2003; Ivancevich, 2008) and because it is regarded as an outstanding need theory due to the breadth of its coverage of human-need types (Au et al., 2008; Yang et al., 2011). ERG theory assumes that human behaviors are driven by three core intrinsic needs: existence needs, relatedness needs, and growth needs. *Existence needs* refer to the basic requirements of human existence, and can be subdivided into safety, psychological, and material needs. *Relatedness needs* are humans' desires to maintain interpersonal relationships with significant other people via processes of sharing and mutuality. Lastly, *growth needs* involve an individual's creative or productive efforts toward achieving personal development, self-esteem, and self-actualization. The questionnaire items of the second and third parts were responded to using five-point Likert-scale questions, with the responses for preferences ranging from 1=very unimportant to 5=very important, and those for perceptions of usefulness, from 1=strongly disagree to 5=strongly agree.

3.2 Data collection

The questionnaires, in online and paper formats, were distributed to 511 Taiwanese citizens recruited via snowball sampling in March and April 2019. Among the 487 online questionnaires, 56 had missing or inconsistent answers and were therefore omitted from further analysis. All of the 24 paper questionnaires had valid responses.

Therefore, we collected 455 valid questionnaires across both formats, an overall response rate of 89%. Chi-square test of independence was conducted for comparing the sample and the whole population in Taiwan, as shown in **Table A.4**. The results show that the sample proportions are consistent with the population proportions in terms of gender (Chi-square value = 0.105, P-value = 0.745) and location (Chi-square value = 0.446, P-value = 0.051). Some slight differences can be observed for the age, education, and occupation proportions. Specifically, more number of the population aged between 20-30, with a bachelor's degree, and the students were sampled, which can be explained by these three population groups were more easily to be approached in the online questionnaire survey. Despite this, other population groups were relatively well represented by the sample data.

3.3 Analysis methods

Our data analysis was conducted in three steps. In the first, we examined the reliability and validity of the questionnaire's measurements using confirmatory factor analysis (CFA): a technique that focuses on how well latent variables – i.e., those that cannot be observed directly (Bollen, 2002) – can be measured indirectly via a set of observed variables (Byrne Barbara, 2016). In the present study, the latent variables were the respondents' preferences about seven dimensions of SC services (PSERG – PSHEL in **Table A.3**) and their perceptions of the usefulness of SC services (PERPT in **Table A.3**). The observed variables consisted of all the questionnaire items on preferences and

perceptions (A1 – H3 in **Table A.3**).

In the second step, we explored the respondents' preferences and usefulness perceptions using descriptive statistics, including proportion, mean, and standard deviation. And in the third, we investigated whether there were significant differences in these citizens' preferences for different dimensions of SC services, as well as whether any such significant differences might be related to their demographic characteristics, using inference statistics including *t*-test, Analysis of Variance (ANOVA) and Tukey's post-hoc analysis. All these analyses were conducted using the R programming language. CFA, in particular, was conducted using the R package "lavaan" developed by Rosseel (2012).

4. Data analysis and results

4.1 Reliability and validity

CFA results regarding the reliability of latent variables is expressed using Cronbach's alpha. A Cronbach's alpha value larger than 0.7 indicates that the latent variable in question can be measured by the observed variables with a high level of internal consistency (Nunnally, 1994). In this case, CFA produced Cronbach's alpha values for the latent variables ranging from 0.774 to 0.890 (**Table 2**), indicating that the questionnaire measurements were reliable.

Table 2. Reliability test.

Latent	PSERG	PSENV	PSPEO	PSLIV	PSTRA	PSSAF	PSHEL	PERPT

variable								
Cronbach's alpha	0.774	0.869	0.890	0.860	0.882	0.877	0.880	0.825

Note: The full form of the latent variables can refer to Table 1.

Validity testing of questionnaire measurements is divided into two types, convergent validity and discriminant validity (Campbell & Fiske, 1959). The former refers to how well a latent variable is measured by its observed variables, and is a combination of three indicators: standardized factor loading, average variance extracted (AVE) and composite reliability (CR) (Hair et al., 1998). Hair et al. (1998) recommended that, in tests of convergent validity, the standardized factor loadings of the observed variables should be greater than 0.5. Here, all such variables had standardized factor loadings greater than 0.5, indicating good convergent validity of the questionnaire measurements (**Table 3**). Fornell and Larcker (1981) suggested that latent variables' AVE and CR should be greater than 0.5 and 0.7, respectively. In our results, all the latent variables also exceeded these thresholds (**Table 3**).

Table 3. Convergent validity test.

Latent variable	Observed variable	Std. factor loading (> 0.5)	P-value	CR (>0.7)	AVE (>0.5)
PSERG	A1	0.669	0.000***	0.777	0.509
	A2	0.589	0.000***		
	A3	0.717	0.000***		
	A4	0.749	0.000***		
PSENV	B1	0.734	0.000***	0.872	0.530
	B2	0.744	0.000***		
	B3	0.746	0.000***		
	B4	0.718	0.000***		
	B5	0.735	0.000***		
	B6	0.703	0.000***		
PSPEO	C1	0.759	0.000***	0.892	0.580

	C2	0.737	0.000***		
	C3	0.718	0.000***		
	C4	0.798	0.000***		
	C5	0.791	0.000***		
	C6	0.764	0.000***		
PSLIV	D1	0.611	0.000***	0.864	0.571
	D2	0.718	0.000***		
	D3	0.757	0.000***		
	D4	0.602	0.000***		
	D5	0.723	0.000***		
	D6	0.774	0.000***		
	D7	0.632	0.000***		
PSTRA	E1	0.780	0.000***	0.885	0.658
	E2	0.827	0.000***		
	E3	0.857	0.000***		
	E4	0.779	0.000***		
PSSAF	F1	0.830	0.000***	0.879	0.641
	F2	0.806	0.000***		
	F3	0.786	0.000***		
	F4	0.789	0.000***		
PSHEL	G1	0.767	0.000***	0.881	0.652
	G2	0.790	0.000***		
	G3	0.836	0.000***		
	G4	0.830	0.000***		
PERPT	H1	0.739	0.000***	0.828	0.623
	H2	0.836	0.000***		
	H3	0.777	0.000***		

Note: The full form of the latent variables can refer to Table 1; CR denotes composite reliability; AVE denotes average variance extracted.

Discriminant validity, on the other hand, refers to the degree to which latent variables are distinguishable from one another. In general, this type of validity can be detected by any one of three criteria, i.e., cross-loading of indicators, the Fornell-Larcker criterion, and the heterotrait-monotrait ratio of correlation (HTMT) (Ab Hamid et al., 2017). The present study adopted HTMT for assessing discriminant validity because that criterion outperforms both the Fornell-Larcker criterion and cross-loading of indicators in both specificity and sensitivity (Henseler et al., 2015). An HTMT value

close to 1 suggests that two latent variables lack discriminant validity. Our latent variables' HTMT values were all smaller than 0.9, showing – per Gold et al. (2001) – that all were distinguishable from one another, and thus that the questionnaire measurements had good discriminant validity (**Table 4**).

Table 4. Discriminant validity test.

Latent variable	PSERG	PSENV	PSPEO	PSLIV	PSTRA	PSSAF	PSHEL	PERPT
PSERG	-	-	-	-	-	-	-	-
PSENV	0.807	-	-	-	-	-	-	-
PSPEO	0.704	0.741	-	-	-	-	-	-
PSLIV	0.644	0.744	0.726	-	-	-	-	-
PSTRA	0.593	0.666	0.575	0.757	-	-	-	-
PSSAF	0.719	0.697	0.637	0.770	0.796	-	-	-
PSHEL	0.718	0.723	0.709	0.765	0.766	0.869	-	-
PERPT	0.734	0.744	0.800	0.756	0.784	0.849	0.865	-

Note: The discriminant validity is assessed by the Heterotrait-Monotrait ratio of correlation.

4.2 SC services preferences

By ranking the mean scores our respondents assigned to each of the 35 questionnaire items relating to SC service preferences, we arrived at a list of their 10 most preferred SC services. As shown in **Table 5**, eight of these top 10 were from the hard domain. Specifically, two smart-safety services ranked in second and third place: i.e., accident-scene image transmission and monitoring service and public safety protection and crime prevention service. This result indicates that the respondents preferred the SC services that could help to improve the safety and stability of the social environment. Three other

top-10 SC services belonged to the smart-environment dimension. They were water-management service, epidemic prevention and surveillance service, and natural-disaster mitigation and surveillance service. This result implies that the respondents paid much attention to how the use of ICT could help to achieve sustainable usage of freshwater resources and reduce the risk of infectious disease and natural disasters. One exemplar of the smart-transport dimension, namely, intelligent car-parking management service, ranked fifth. Two services of the smart-health dimension – remote medical service and e-hospital service– ranked seventh and 10th, respectively. This result indicates that the respondents preferred the use of ICT systems to help them improve their daily-life experience, including car-parking experience and the diagnosis and treatment experience.

Interestingly, the top-rated SC service belongs to the soft domain: the smart-living dimension. This was the welfare and social inclusion service, indicating that the respondents showed much concern on the delivery of SC services for serving the needs of minority groups, e.g., people with hearing impairment or deafness. And the fourth place also belongs to the soft domain "the smart-living dimension," which is accorded to the automatic fine payment notification service. This result adds further support to the previous implication that the respondents preferred the use of ICT tools to enhance their daily-life experience.

Table 5. Top 10 SC services based on citizens' preferences.

Ranking	SC services	Mean	SD

1	D7: Welfare and social inclusion service	4.49	0.75
2	F2: Accident scene image transmission and monitoring service	4.46	0.74
3	F1: Public safety protection and crime prevention service	4.43	0.75
4	D1: Automatic fine payment notification service	4.42	0.87
5	E1: Intelligent parking management service	4.40	0.84
6	B3: Water management service	4.39	0.78
7	G2: Remote medical service	4.39	0.78
8	B1: Epidemic prevention and surveillance service	4.38	0.77
9	B2: Natural disasters mitigation and surveillance service	4.38	0.80
10	G3: E-hospital service	4.38	0.80

We further explored the differences in the respondents' preferences for different dimensions of SC services using ANOVA. An individual's preference for such a dimension was measured by the average score s/he assigned to all SC services of that dimension. For instance, a respondent's preference for smart-energy dimension, PSERG – was measured as the sum of his/her responses to A1 through A4, divided by 4. As shown in **Fig. 2**, all of the seven dimensions of SC services were rated as highly preferred, i.e., their mean scores were all higher than 4. However, with means of 4.092 and 4.217, respectively, the smart-people and smart-living dimensions had relatively lower preference scores than the other five dimensions. ANOVA results showed that there were statistically significant differences in our respondents' preferences for different dimensions of SC services (**Table 6**, $p<0.001$).

Table 6. The ANOVA table for citizens' preferences for SC services in different dimensions.

	Df	Sum Sq	Mean Sq	F-value	P-value
Dimension	6	30.8	5.139	10.64	0.000***
Residuals	3178	1534.7	0.483		

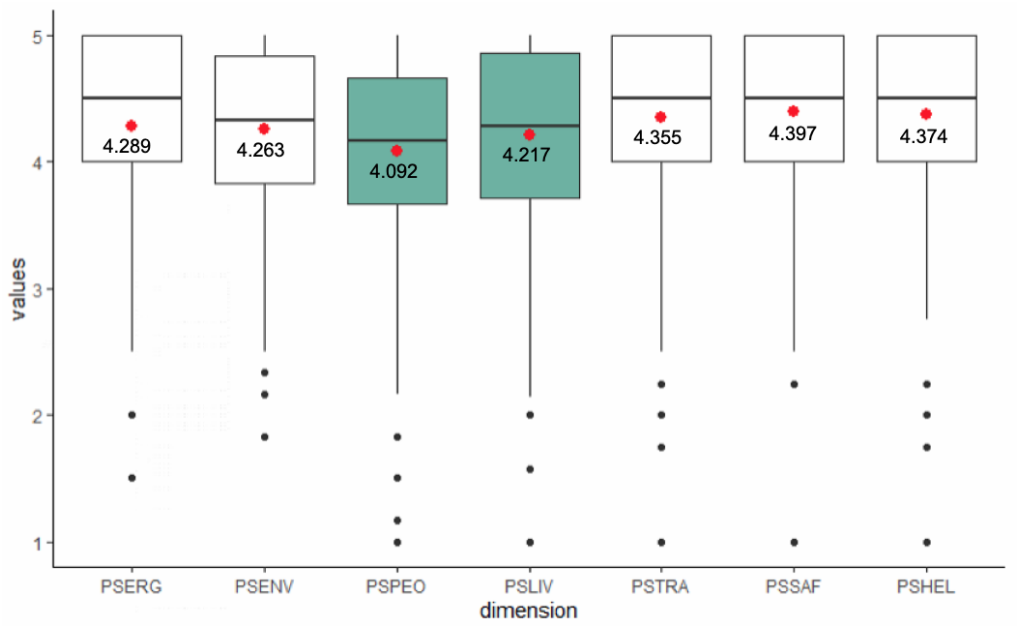

Fig. 2. Citizens' preferences for SC services in seven dimensions. (The red dots denote the mean value; the dimension with green color denotes its mean value is significantly lower than other dimensions in Tukey's post hoc analysis.)

The results of Tukey's post-hoc analysis confirmed that the preference ratings assigned to two soft-domain dimensions - the smart-people and smart-living - were significantly lower than those assigned to the other five hard-domain dimensions (**Table 7**, $p<0.05$). Specifically, the difference in mean score between the smart-people dimension and the top five hard-domain dimensions ranged from -0.305 to -0.197. Although there was little difference between the smart-living dimension and the smart energy and smart environment dimension, the mean score of the smart-living dimension was significantly lower than other three hard-domain dimensions, including the smart-transport ($p=0.043$), smart-safety ($p=0.002$) and smart-health ($p=0.012$) dimensions, with mean-

score differences ranging from -0.180 and -0.137. These results are a further indication of the respondents' relatively higher preferences for SC services from the hard domain over those from the soft domain.

Table 7. Tukey's post hoc analysis for different dimensions of SC services.

Dimension (I)	Dimension (J)	Difference of means (I)-(J)	95% Confidence interval	P-value
PSPEO	PSERG	-0.197	(-0.333, -0.061)	0.000***
	PSENV	-0.171	(-0.307, -0.035)	0.004**
	PSTRA	-0.263	(-0.127, -0.399)	0.000***
	PSSAF	-0.305	(-0.169, -0.441)	0.000***
	PSHEL	-0.282	(-0.146, -0.417)	0.000***
PSLIV	PSTRA	-0.137	(-0.002, -0.274)	0.043*
	PSSAF	-0.180	(-0.044, -0.316)	0.002**
	PSHEL	-0.157	(-0.021, -0.293)	0.012*

Note: Only significant differences of means are represented in this table. *p < 0.05, **p<0.01, ***p<0.001.

4.3 SC services usefulness perceptions

Most of the members of our sample acknowledged the positive role of SC services in meeting human needs. However, the number of respondents who held a positive view of such services' fulfillment of existence needs was slightly higher than the number who held such a view of their fulfillment of either relatedness or growth needs (**Table 8**). Specifically, 94% of the respondents reported that they agreed or strongly agreed that SC services could give them a more stable and safer life (i.e., fulfilled existence needs), as compared to 89.2% who agreed or strongly agreed that such services could benefit their interpersonal relationships with significant others (relatedness needs), and 89.7% who agreed or strongly agreed that such services were conducive to personal

development, self-esteem, and self-actualization (growth needs). Relatively few of the respondents – i.e., between 5.9% and 10.7%, depending on need category – expressed neutral or negative attitudes about the role of SC services in meeting human needs.

Table 8. Proportion of citizen's perceptions of the usefulness of SC services (N=455).

The realization of human needs	Very disagree	Disagree	Neutral	Agree	Very agree
H1: Existence	0.0%	0.4%	5.5%	38.2%	55.8%
H2: Relatedness	0.4%	0.2%	10.1%	39.1%	50.1%
H3: Growth	0.2%	0.4%	9.7%	46.4%	43.3%

Next, we analyzed the potential relationships between the respondents' demographic characteristics and their perceptions of the usefulness of SC services using *t*-tests and ANOVAs, depending on whether the demographic variable was binary or categorical. The dependent variable, *smart-city perception*, was the summarized score of H1, H2, and H3, which ranged from 4 to 15 with a mean value of 13.2. The results indicate that the respondents' smart-city perception was not significantly related to their genders, educational attainment, or occupations **(Table 9**, $p>0.05$). However, there were statistically significant differences in the respondents' smart-city perception both across age groups and among geographic locations (**Table 9**, $p<0.001$).

Table 9. Relationship between smart-city perception and demographic characteristics.

Demographic variable	Type	P-value	Method
Gender	Binary	0.299	t-test
Age	Categorical	0.000***	ANOVA (need post hoc analysis)
Location	Categorical	0.000***	ANOVA (need post hoc analysis)
Education	Categorical	0.389	ANOVA
Occupation	Categorical	0.179	ANOVA

Note: *** p < 0.001; ANOVA denotes Analysis of Variance.

We further explored which age groups and location groups differed from others in terms

of mean smart-city perception using Tukey's post-hoc analysis (**Table 10**). This showed that the respondents aged between 41 and 50 had significantly higher mean smart-city perception than those aged 20 and below (p<0.05) and those aged between 21 and 30 (p<0.01). Respondents from southern Taiwan also had a slightly, but significantly higher mean smart-city perception than those from the north (p<0.01) with a confidence interval between 0.017 and 1.159. Also, respondents from the outlying island region had significantly lower mean smart-city perception than those from central (p<0.05), southern (p<0.01), and eastern Taiwan (p<0.05). However, given how few respondents (n= 7) lived in the outlying islands, under-coverage sampling bias could explain this.

Table 10. Tukey's post hoc analysis for different age and location groups.

Demographic variable	Group (I)	Group (J)	Difference of means (I)-(J)	95% Confidence interval	P-value
Age	4	1	1.495	(0.101, 2.889)	0.027*
	4	2	0.931	(0.169, 1.691)	0.007**
Location	3	1	0.588	(0.117, 1.059)	0.006**
	5	2	-2.074	(-3.955, -0.193)	0.022*
	5	3	-2.199	(-3.991, -0.406)	0.007**
	5	4	-2.857	(-5.348, -0.365)	0.015*

Note: The group coding is shown in Table 2; Only significant differences of means are represented in this table. *p < 0.05, **p<0.01.

5. Discussion

5.1 Discussion

We found that most of the Taiwanese citizens we surveyed acknowledged the importance of SC services and their usefulness in the realization of human needs. All

seven broad dimensions of SC services received mean scores higher than 4 out of a possible 5. Additionally, nearly 90% of the respondents reported that they agreed or strongly agreed that SC services could help them meet their ERG needs. Such high-level positive attitudes toward SC services among Taiwanese citizens may be ascribable, at least in part, to the high penetration and generally high quality of such_services in Taiwanese cities. Since 2002, which saw the launch of the central government's Electronic Taiwan initiative, Taiwan has developed a mature ICT environment for delivering SC services, featuring Internet-usage and ICT service-penetration rates of more than 80%; moreover, Taiwan ranks world number one in ICT-hardware market share (Institute for Information Industry, 2017). Given this context, Taiwanese citizens are perhaps unusually aware of the importance of SC services, and expect their well-being and quality of life to improve if they use them (Chou & Hsu, 2017). This finding appears to add further empirical support to a study by Yeh (2017), which found that ICT-based SC services received widespread acceptance across Taiwan's various demographic groups due to the very high level of SC service diffusion there.

Taiwanese citizens expressed relatively higher preferences for SC services from the hard domain over those from the soft domain. Eight of the 10 most-preferred specific SC services were drawn from four hard-domain dimensions, i.e., smart safety, smart transport, smart environment, and smart health. This finding is consistent with that of Kwon and Kim (2007), who found that South Koreans had higher-level requirements for those ubiquitous smart services that related to nature-friendliness, health, and safety.

Our preference rankings also imply that Taiwanese citizens are currently focused on how the use of advanced ICT could improve the delivery of critical-infrastructure services and the management of natural resources, as a means of satisfying existence needs in particular. According to ERG theory, this category of needs is the most basic, concrete, and fundamental. The idea that Taiwanese people look to SC services primarily to meet existence, rather than relatedness or growth needs, is also supported by our findings directly. That is, the respondents who expressed a belief that SC services are conducive to the fulfillment of existence needs slightly outnumbered those who saw them as conducive to meeting the other two need categories.

That being the case, a possible explanation for our respondents' relatively low preferences for SC services from the soft domain is that they associated that domain with their lower-priority needs, i.e., relatedness and growth. In other words, it may indicate that Taiwanese citizens perceive SC services to be more relevant to achieve a stable, safe, and convenient life than to improve their interpersonal relationships, boosting their self-esteem, or achieving self-actualization. Such an interpretation echoes prior work by Yeh (2017), who pointed out that Taiwanese people tend to appreciate the functionality of the ICT-based SC services, but not to feel that using them is a mark of social engagement. Another possible explanation is that the respondents may perceive the urban services in soft domains is not necessary to be delivered by ICT-based smart ones; instead, they may prefer the soft-domain services to be delivered in a traditional non-smart way, or to be improved by appropriate policy adjustments.

Our respondents' places of residence within Taiwan and their ages seemed to be related to their perceptions of SC services' ability to fulfill human needs, whereas their genders, educational attainment, and occupations were not. These results are broadly consistent with those of two previous studies that investigated attitudes and behaviors relating to urban services (Belanche et al., 2016) and ICT-based SC services (Yeh, 2017). Specifically, Belanche et al. (2016) found that the education level of Spanish citizens was positively correlated with their usage of urban services, while gender and age showed no effect; and Yeh (2017) reported that Taiwanese citizens' ages, genders, and education levels did not influence their service acceptance. Our finding that Taiwanese citizens aged 41 to 50 had more positive perceptions of SC services than those 30 and younger may reflect the fact that middle-aged citizens have, as adults, lived through the dramatic advancement of ICT and the digital transformation of Taiwan's cities discussed above. As such, they may be more likely than younger people to appreciate the benefits of SC services, due to having a "pre-SC baseline" for comparison. This finding implies that future rollouts of SC services should focus on how these new services will improve citizens' quality of life, relative to their existing living standards.

5.2 Policy implications

In line with the above findings, we can make the following set of policy suggestions regarding the strategic positioning of SCs for Taiwan's city administrators, with the goal of increasing Taiwanese citizens' usage and acceptance of SC services in the hard

and soft domains.

Maintaining Taiwan's strength in SC development by investing in advanced and emerging smart technologies. ICT systems are fundamental foundations for the development of SC, because most SC services are delivered via ICT-enhanced urban infrastructure and applications. Our study has revealed that Taiwanese citizens have highly positive views of the importance and usefulness of SC services, partly ascribable to the high penetration rate of SC services in Taiwan's cities, which in turn is related to Taiwan's ICT strength more generally. To help maintain that strength – and sustain the existing positive feedback loop among ICT, SC, and SC attitudes – city administrators are encouraged as part of future SC development to invest in advanced and emerging smart technologies, including but not limited to fifth-generation (5G) mobile-communication technology, artificial intelligence (AI), virtual/augmented reality (V/AR), blockchains, robots, and unmanned aerial vehicles (Ahad et al., 2020; Bhushan et al., 2020; Singh et al., 2020).

Giving priority to the delivery of SC services in the hard domain that contribute to the realization of existence needs. Thanks to advancements in ICT, the delivery of services in the hard domain is capable of being simultaneously "smart" and "people-centric": that is, the sensors embedded in city settings, combined with cloud computing and software solutions, allow high-efficiency handling of urban "big data" that in turn enables real-time responses to citizens' needs. Because the usage of SC services from the hard domain can satisfy fundamental needs such as for public safety, personal

security and health, Taiwanese citizens currently exhibit relatively higher preferences for services from that domain. In line with citizens' preferences, city administrators in Taiwan should prioritize the hard domain in future SC development.

Encouraging usage of SC services from the soft domain by stimulating citizens' desires to fulfill relatedness and growth needs. Although our respondents exhibited lower preferences for SC services from the soft domain than for those from the hard domain, this should not be taken to mean that the former are unimportant to them. Indeed, SC services in the soft domain, including education, culture, tourism, innovation/entrepreneurship, human capital management, e-government, and welfare/social inclusion, are crucial to citizens' realization of higher-order human needs, namely, relatedness and growth needs. To increase usage of soft-domain SC services, such services should be delivered in ways that can stimulate people's desire to improve their interpersonal relationships, develop themselves, boost their self-esteem, and achieve self-actualization. For example, the delivery of e-government and e-democracy services should be capable of inspiring citizens' engagement and participation in local governments' decision-making processes, through which they might feel a sense of achievement that increases their self-esteem while also generating useful solutions for local communities.

6. Conclusions and recommendations

People-centric SC development and service improvement require city administrators to

have clear, detailed understandings of citizens' needs and preferences. Taking Taiwan as a case study, we surveyed 455 Taiwanese citizens regarding their preferences for 35 SC services of seven dimensions in two domains, as well as their perceptions of the usefulness of SC services to the realization of human needs. We found that most of the respondents acknowledged the importance of SC services and their usefulness in the realization of human needs. Such highly positive attitudes towards SC services among Taiwanese citizens may be ascribable to the high penetration rate of such services in Taiwan cities. Meanwhile, our respondents' relatively strong preferences for the hard domain over the soft one, based on the results, could imply that city administrators could prioritize the SC services in hard domain for future SC development. Nonetheless, because SC services from the soft domain are also crucial to satisfying the citizens' needs, and especially their relatedness and growth needs, usage of such services should also be encouraged; for example, by stimulating citizens' desires to enhance their interpersonal relationships, personal development, self-esteem, and self-actualization.

The present study has yielded valuable insights into the strategic development of SCs, which can serve as useful references for both academics and practitioners (e.g., city administrators, urban planners, SC services designers and providers) who are interested in people-centric SC development. To the best of the authors' knowledge, the present study is the first evidence-based research on the citizens' preferences and perceptions about SC services from the perspective of need theories. Previous empirical research has generally discussed the citizens' usage and acceptance of SC services, rather than

scrutinizing their actual preferences for different types and dimensions of SC services. Besides, anchoring the present study in Alderfer (1969)'s ERG theory provides a theoretical lens for better understanding the citizens' underlying motivations for the usage and acceptance of SC services. Previous empirical studies have mainly investigated the benefits of SC services for citizens, or the key factors influencing the citizens' usage of SC services, rather than linking the relationship between the citizens' perceptions of SC services with their underlying existence, relatedness, and growth needs. Hence, the present study not only helps to inform local governments' decision-making on SC development in a people-centric and locality-specific manner, but also well complements existing academic research on the citizens' usage and acceptance of SC services.

The present study throws up many interesting questions in need of further investigation. First, the citizens' relative low preferences for SC services in soft domains may imply that the citizens may prefer the urban services in soft domains to be delivered in a traditional non-smart way, or to be improved by appropriate policy adjustments, rather than ICT-based smart ones. Future studies are encouraged to further investigate the citizens' perceptions of the necessity of providing soft-domain urban services using ICT-based tools and compare the results with the present study. Second, the citizens' preferences for SC services may be influenced by a set of SC-service alternatives available to them. It is possible that the citizens may prefer one SC service but have no real need for it, which may be mainly due to the lack of better alternatives for fulfilling

their human needs. Future studies can further explore whether a "no-choice preference" phenomenon (Dhar, 1997) exists among the citizens' preferences for SC services, namely, the citizens may decide not to choose a specific SC service in case no single SC-service alternative has a decisive advantage for satisfying their' existence-, relatedness-, and growth needs. Finally, citizens' preferences and perceptions about SC services are likely to vary sharply across cities, countries, and world regions, depending on what SC services have been delivered; ICT penetration; and a host of other geographically, societally, and technologically specific contextual variables. Hence, the present study's results should not be generalized to other countries except with great caution. By the same token, it would be very interesting to compare our results against those of parallel research in other countries that have different endowments regarding the design and delivery of SC services.

However, the present study is still subject to some limitations that need to be acknowledged. One is that its data collection was conducted via snowball sampling, and the demographic composition of the sample therefore was not totally matched to that of the overall Taiwanese population. If possible, future studies are encouraged to conduct random sampling technique (e.g., telephone interview via random digital dialing method) to investigate the citizens' preferences and perceptions about SC services in their own countries or cities. Second, some personal determinant factors that may influence the citizens' preferences and perceptions about SC services have not been considered in the present questionnaire design. For example, some questionnaire items

may require the respondents to have some basic background knowledge on the ICT technologies in SC development, e.g., microgrids and AR, which may influence their preferences and perceptions about SC services. Future studies are encouraged to further investigate how citizens' different ICT knowledge, personal innovativeness, SC awareness may influence their SC-services preferences and perceptions. Third, some SC services mentioned in the questionnaire survey may be too technical oriented or specific to be clearly understood by the general public. It is possible that some bias may exist in the evaluation of citizens' preferences and perceptions if they have difficulty in understanding the meanings of SC services provided in the questionnaire survey. Such understanding bias can be reduced by necessary explanations for some difficult technical terms through face-to-face survey or telephone survey in the future. Finally, in the current version of questionnaire design, different fields of SC services (A1-D7) were measured by descriptive contents with specific examples of ICT applications (e.g., AR and healthcare APP). Bias may exist in the evaluation of citizens' preferences if they feel a stronger need for broader fields of SC services rather than specific ICT applications, or vice versa. But such field-application evaluation bias is difficult to be mitigated by questionnaire design because ICT applications for SC services will change along with the development of science and technology. Nonetheless, it would be interesting to compare similar research on citizens' needs and preferences about SC services conducted in different generations of SC developments. It is expected that wider applications of advanced technologies such as 5G, AI, and Blockchains will boost

more advanced ICT-based SC services in different domains, and the citizens' needs and preferences about these services are worthy of further explorations.

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Appendices

Table A.1. Examples of SC solutions in Taiwan cities.

Region	City or county	SC solutions
Northern region	Keelung City	- Smart emergency rescue system: The combination of the smart wearable device "smart glasses" and wireless vital signs monitor for the use of emergency rescue
	Taipei city	- Advanced metering infrastructure - An application program (APP) for integrating information on disaster prevention - Healthcare ATM for providing healthcare information services such as personal healthcare record query and download - Smart parking APP
	New Taipei city	- Intelligent face recognition system for public safety - "Medical Fairy" APP that integrates medical care services, such as consultation number inquiry and medical care information. - Mobile payment platform - New Taipei government service cloud system for citizens' applications, consultations, and petitions
Central	Taichung city	- Taichung city geographic and disaster prevention information system

region		- Age-friendly mobile navigation information platform
	Nantou county	- Sun Moon Lake low-carbon and smart tourism project
	Changhua county	- The automatic vehicle monitoring platform
Southern region	Tainan city	- Smart epidemic prevention platform using GIS and internet of things for dengue fever control - Tainan city government citizen services APP named Open Tainan 1999
	Kaohsiung city	- Agricultural real-time human resource platform named AgriMax - Household registration services APP - Cross-region traffic control platform for Kaohsiung city and Pingtung county
	Pingtung county	- The combination of the solar photovoltaic system and microgrid system
Eastern region	Hualien county	- The combination of unmanned aerial vehicles with cameras and mobile devices for dealing with traffic accidents
	Taitung county	- E-service home delivery project for providing government services to citizens in their home - Remote home-based and community-based care services APP - Online agricultural mall for marketing local agricultural products
Outlying island region	Matsu islands	- The integration of smart tourism and transportation resources

Note: The information was mainly obtained from the website: http://smartcity.org.tw/index.php.

Table A.2. Empirical studies on SC services from the citizens' perspectives.

No	Study	Study area	Research objective	Data collection	Analysis method	Investigated variables	Major findings
1	De Guimarães et al. (2020)	A city in the Northeast of Brazil	Examine how the factors of smart governance influence the citizens' Quality of Life (QoL)	Questionnaire survey of 829 citizens	Structural equation modeling (SEM)	Y: QoL X: Five factors of smart governance: transparency, collaboration, participation and partnership, communication, and accountability	1) All the smart-governance factors are positively related to QoL 2) Transparency has the highest influence relation over QoL
2	Vidiasova and Cronemberger (2020)	St. Petersburg, Russia	Investigate the diff erences between perceptions of authorities and citizens for local smart city initiatives	Questionnaire survey of 421 citizens and 375 civil servants	Descriptive statistics	Y: Smart city awareness, prioritization, expectations, and readiness to participate X: Types of respondents: citizens or civil servants (authorities)	There are discrepancies between the perceptions of the citizens and the authorities in understanding smart city endeavors
3	Lin et al. (2019)	Chinese smart cities	Examine the relationships between the residents' SC-services experiences and their subjective well-being	Questionnaire survey of 247 citizens	Hierarchical regression analysis	Y: Subjective well-being X: SC-services experience on safety, usefulness, convenience	All the SC-services experience factors are positively related to subjective well-being

4	Xu and Geng (2019)	Wuhan city, China	Propose the frameworks of people-centric service intelligence for smart city applications	Review of 16 SC practices in Wuhan city	Framework analysis	1) Theoretical framework: computational intelligence and Maslow (1958)'s hierarchy-need theory 2) Technical framework: Service-, data-, and infrastructure layer	The reviewed SC practices only cover the physiological, and safety needs of citizens, but overlook their belonging, esteem, and self-actualization needs
5	Macke et al. (2018)	The city of Curitiba, Southern Brazil	Explore the citizens' QoL factors and how these factors influence on their satisfaction of urban services	Questionnaire survey of 398 citizens	1) Factor analysis 2) Linear regression analysis	Y: Satisfaction of urban services X: QoL factors	1) Four QoL factors: socio-structural relations, environmental well-being, material well-being, and community integration 2) All the QoL factors are positively related to citizens' satisfaction
6	Yeh (2017)	Taiwan	Investigate how different factors affect citizens' acceptance of ICT-based SC services and how the SC-services acceptance influence citizens' QoL	Questionnaire survey of 1,091 citizens	SEM	Y: QoL X: Innovation concept, city engagement, service quality, perceived privacy, trust, personal innovativeness; Acceptance of SC services	1) All the factors, except for city engagement, contribute to the acceptance of SC services 2) High acceptance of SC services contributes to QoL

7	Belanche et al. (2016)	The city of Zaragoz, Spain	Examine the influence of citizens' city-attachment levels and personal determinants on their usages of urban services	Questionnaire survey of 464 citizens	SEM	Y: The usage of urban services X: City attachment, attitude, demographic variables	1) Attitude, smart-card usage, and education are positively related to the usage of urban services 2) City attachment indirectly influences the usage of urban services through attitude
8	Kwon and Kim (2007)	South Korea	Investigate what kinds of ubiquitous space services should be provided for local citizens in U-city development	Questionnaire survey of 238 citizens	Descriptive statistics	Y: Ubiquitous space services X: Alderfer (1969)'s Existence, Relatedness, and Growth theory and Herzberg (1959)'s two-factor theory	1) Citizens' existence needs were overemphasized in ubiquitous space services provision, while the relatedness and growth needs had less focus 2) Citizens' hygiene factors such as safety and convenience were more emphasized

Note: Y denotes the response variable(s); X denotes the explanatory variables.

Table A.3. Questionnaire measurements.

Dimensions	Items	Descriptions
Demographic features of respondents	Gender	Male; Female.
	Age	20 and below; 21-30; 31-40; 41-50; 51-60; Above 60.
	Location	Northern region; Central region; Southern region; Eastern region; Outlying island region.
	Education	Junior high school or below; Senior high school; Bachelor; Master or above.
	Occupation	Military officers/civil servants/educational personnel; Service sector; Finance sector; Manufacturing sector; Information/technology sector; Communication/advertising/design sector; Medical health sector; Agriculture/forestry/fishery/animal husbandry sector; Student; Housekeeper/retiree; Others.
Preference for smart energy (PSERG)	A1: Smart grids service	To deliver sustainable, economic, reliable, and secure electricity supplies through optimized two-way communications between the power grids and end-users and taking into account the energy-use behaviors of all the connected users.
	A2: Renewable energies service	To provide solar photovoltaic service, solar heat service, geothermal/wastewater heat recovery service, wind power generation service through the construction of renewable energy equipment that can exploit regenerative or inexhaustible energies from nature.
	A3: Microgrids service	To deliver urgent and necessary electricity within the localized energy grids that coordinate distributed energy resources (e.g., solar panels) in times of crisis such as natural disasters (e.g., storms) or power outages.
	A4: Intelligent building energy management service	To improve building energy efficiency by the use of intelligent building energy management system, which can implement an automatic energy demand response for achieving energy saving and carbon reduction.
Preference for smart environment (PSENV)	B1: Epidemic prevention and surveillance service	To prevent the epidemic spread (e.g., dengue virus) and conduct real-time surveillance of the epidemic through the construction of epidemic prevention and online surveillance platform.

	B2: Natural disasters mitigation and surveillance service	To reduce the adverse impacts of multiple natural disasters (e.g., flood, soil and rock flow, earthquake, typhoon, tsunami) on human and properties by real-time collecting and reporting of disaster information, disaster forecast and warning, emergency response, rescue operation, etc.
	B3: Water management service	To achieve optimized use of water resources throughout the phases of the hydrological cycle for the municipal, industrial, and agricultural purposes by the use of ICT.
	B4: Waste management service	To reduce the adverse effects of urban waste on human and nature by effectively collecting, recycling, and disposing of urban waste (e.g., daily waste, food waste, noxious waste) by the use of ICT.
	B5: Urban ecosystem management service	To conserve and restore urban ecological services by effective urban ecosystem management such as urban landscape management, roadside tree management, urban park management by the use of ICT.
	B6: Air pollution control service	To improve the quality of air for human health and well-being by air pollution prevention and control such as PM 2.5 real-time detection and monitoring and industrial waste gas recycling by the use of ICT.
Preference for smart people (PSPEO)	C1: E-library service	To provide convenient e-library service for social learning, including e-library resource inquiry service, digital collection service, library portal website and inquiry retrieval interface service.
	C2: Remote education service	To establish online learning platforms for citizens to receive education at any place and any time.
	C3: Digital campus service	To integrate traditional education and digital education by the extensive use of modern ICT tools (e.g., interactive whiteboards, e-learning systems) in public schools.
	C4: Cultural heritage management service	To enable the residents and foreign tourists to have new experience in enjoying the city's cultural heritage by the use of ICT (e.g., augmented reality technologies).
	C5: Innovation and entrepreneurship service	Measures to foster the innovation and entrepreneurship in cities, e.g., the presence of local incubators and city-service APP design competition.
	C6: Human capital management service	Policies to improve human capital investments and attract and retain new talents, avoiding the loss of

		human capital.
Preference for smart living (PSLIV)	D1: Automatic fine payment notification service	If any violation (e.g., traffic violation and late payment) is reported, the fine payment notification system will automatically send a text message or email to inform the citizens of the payment.
	D2: Instant citizen complain service	The citizens can make an instant complaint through smart phones, such as the report of illegal construction, illegal parking, noise, pollution and other issues.
	D3: E-government service	To digitize the public administration by managing government documents and procedures through ICT systems with the aim of optimizing work and offering fast and new government services to citizens.
	D4: E-democracy service	To support ballots by the use of innovative ICT tools, e.g., electronic voting service using smart phones.
	D5: Public spaces management service	To improve the attractiveness of a city through effective care, maintenance, and active management of public spaces by the use of ICT tools, e.g., the provision of information about main places to visit in a city.
	D6: Online city-tourism information service	To enable the tourists to grasp the local tourism information and entertainment events by the use of ICT tools, e.g., the establishment of online tourism information website and the operation of social media pages.
	D7: Welfare and social inclusion service	To reduce barriers for the minority groups in social learning and participation by the use of ICT tools, e.g., barrier-free network space service for the people with hearing impairment or deafness.
Preference for smart transport (PSTRA)	E1: Intelligent parking management service	The integration of real-time parking information system, license plate recognition system, parking guidance system for enabling the drivers to obtain real-time information on available parking spaces, reduce the time to find parking spaces, shorten the search time, and facilitate the drivers to pick up the cars.
	E2: City logistics service	To improve logistics flows in cities by effectively integrating business needs with traffic conditions, geographical and environmental issues.
	E3: Traffic	To provide dynamic, real-time, and multi-modal traffic and transportation information, both pre-trip

	information service	and on-trip with the aim of improving transport and mobility efficiency as well as a high-quality travel experience.
	E4: Electronic traffic payment service	To provide electronic toll collection service, electronic congestion fee collection service, electronic public transport fare payment service, and electronic parking fee payment service for improving traffic management efficiency.
Preference for smart safety (PSSAF)	F1: Public safety protection and crime prevention service	The integration of video surveillance equipment, real-time image exchange platform, police report center, and command center for providing patrol management service, duty dispatch service, public space safety monitoring service, criminal tracking service with the aim of protecting public safety and preventing crimes.
	F2: Accident scene image transmission and monitoring service	The use of ICT systems (e.g., video surveillance equipment) to send back the major criminal cases, traffic incidents or crowd gathering scenes to the police station (command center) by wire or wireless way, so as to instantly grasp the accident scene information and dispatch the manpower and material resources to the scene.
	F3: City-border network transmission and monitoring service	To set up the network transmission and monitoring system on the roads adjacent to the county and city borders for monitoring the vehicles entering and leaving the urban area, so as to expand the public security tentacles.
	F4: Vehicle anti-theft service	The use of ICT systems (e.g., wireless communication and GPS global positioning) for vehicle identification and stolen car identification.
Preference for smart health (PSHEL)	G1: E-healthcare service	The use of ICT tools (e.g., healthcare APP) to provide electronic healthcare services, including personal healthcare information service, medication reminder service, e-fitness service.
	G2: Remote medical service	The provision of remote medical service (e.g., remote medical treatment service, visiting patients service, and emergency medical service) by integrating medical care communication platform, remote-end information technology, and the personal cloud health database.
	G3: E-hospital service	The use of ICT systems to increase the efficiency of disease prevention, diagnosis and treatment in hospital and the provision of electronic hospital services such as hospital information service, smart sickbed service, electronic prescription service.

	G4: E-elderly care service	The use of ICT systems (e.g., online platform and smart home devices) for supporting the delivery of home-based and community-based care services for the elderly, including hospitality services, activities of daily living care services, specialized memory care services.
Perception of the usefulness of SC services in the realization of human needs (PERPT)	H1: Existence	SC services bring me a more stable and safer life.
	H2: Relatedness	SC services contribute to my interpersonal relationship with significant other people.
	H3: Growth	SC services are conducive to my personal development, self-esteem, and self-actualization.

Table A.4. Chi-square test of independence between the sample and the whole population in Taiwan.

Attributes	Classification (Coding)	Sample proportion (%)	Population proportion (%)	Chi-square	P-value
Gender	Male (1)	52.50	49.69	0.105	0.745
	Female (2)	47.50	50.31		
Age	<= 20 (1)	3.50	8.17	20.139	0.001***
	21-30 (2)	42.90	18.55		
	31-40 (3)	17.40	20.05		
	41-50 (4)	11.40	18.98		
	51-60 (5)	19.30	16.64		
	>60 (6)	5.50	17.61		
Location	Northern region (1)	42.40	46.56	0.446	0.051
	Central region (2)	11.00	23.69		
	Southern region (3)	43.50	27.27		
	Eastern region (4)	1.50	2.17		
	Outlying island region (5)	1.50	0.32		
Education	Junior high school or below (1)	0.40	31.46	52.761	0.000***
	Senior high school (2)	18.00	31.70		
	Bachelor (3)	62.60	32.56		
	Master or above (4)	18.90	4.28		
Occupation	Military officers/civil servants/educational personnel (1)	16.30	7.74	15.72	0.007**
	Service sector (2)	21.30	20.86		
	Finance sector (3)	3.30	3.28		

Manufacturing sector (4)	11.40	23.14
Information/technology sector (5)	4.60	1.98
Communication/advertising/ design sector (6)	2.60	0.87
Medical health sector (7)	2.90	3.48
Agriculture/forestry/fishing/animal husbandry sector (8)	0.90	4.22
Student (9)	23.30	14.86
Housekeeper/retiree (10)	10.50	19.58
Others (11)	2.90	N.A.

Note: Sample number = 455; Census number = 19,541,353, which is the number of populations aged 15 or above. The population proportions for age, gender, education were obtained from the 2010 Population and Housing Census (https://census.dgbas.gov.tw/PHC2010/english/rehome.htm). The population proportions for occupation were obtained from the 2019 Manpower Survey (https://eng.stat.gov.tw/ct.asp?xItem=12683&ctNode=1609&mp=5).

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