Mobile Applications in China's Smart Cities: State-of-the-Art and Lessons Learned

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ABSTRACT

Aligned with the global trend of smartness, China has invested heavily in over 700 smart city projects across over 500 cities. Hundreds of smart city apps, initiated by local authorities, have so emerged in the daily lives of Chinese citizens, but anecdotal evidence showed that these official apps have many problems and deficiencies. This study captures a snapshot of current development and problems of official smart city apps in China. A total of 333 such apps, together with 15,754 comments, were collected, reviewed, and analyzed. The results showed that China's smart city apps fall into three application areas (i.e., smart transportation, smart healthcare, and smart livelihood), of which each provides some promising features and services. However, a range of functional, interface, design, usage, and service-related problems were found in these apps. This paper concluded that further to the very efforts on infrastructure and hardware, local authorities in China, and worldwide need to pay more attention to smart apps in order to maximize potential return of their smart city investments.

KEYWORDS

China, Government, Mobile Application, Smart City, Smart City Apps

1. INTRODUCTION

In recent years, governors and policy makers worldwide have paid much attention to smart cities with aims to enhance efficiency of city infrastructure, utilities and services, as well as to create a more sustainable and liveable environment for citizens (Nam and Pardo, 2011). A smart city can be defined as a place seeking to integrate advanced information and communication technologies with city infrastructure and physical facilities to “address social, economic and environmental problems” (Townsend, 2013).

The set of advanced technologies for building smart cities can range from embedded sensors and hardware facilities in the infrastructure level, to mobile applications (also referred to as apps) in the user end (Nam and Pardo, 2011; Peng et al., 2017). In this context, large-scale deployment of hardware facilities and smart devices in city level will be very costly (Peng et al., 2017). In contrast, the cost of developing a mobile app is fairly low. Consequently, city authorities may often be more inclined to focus on hardware and infrastructural elements of smart cities, and sometimes may underestimate the importance of end-user apps (Peng et al., 2017). However, mobile applications are the actual tools

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used on a daily basis by citizens, who often may not pay much attention to infrastructural facilities. As such, a poorly designed mobile city app may not just lead to citizen dissatisfaction, but will also prevent the realization of intended benefits promised by smart city solutions.

In China, aligned with the global trend of smartness, the country has invested heavily in its national smart city initiative, with over 700 smart city projects across more than 500 Chinese cities initiated since 2012. Accompanied with these smart city investments, local authorities have initiated and launched hundreds of mobile city apps, which can now be easily downloaded by citizens. However, when these official city apps emerged in the everyday lives of millions of Chinese citizens, many design problems and deficiencies affecting their usage have become increasingly apparent to the general public. In fact, this phenomenon does not just occur in China. The study done by Peng et al. (2017) reported a range of crucial problems (e.g. low usability, persistent technical bugs, and functional deficiencies) embedded in a smart parking app provided by the Westminster city council in Greater London. Nevertheless, and despite the imperative need, there is very limited research that aims to capture a holistic view on current development and problems of smart city apps in the world in general and in the Chinese context in particular. The study reported in this paper thus attempts to fill this knowledge gap, by answering two research questions:

- 1) What is the state-of-the-art development of official smart city apps in China?
- 2) What are the levels of user satisfaction as well as problems and deficiencies associated with these city apps?

In order to answer these research questions, a total of 333 smart city apps initiated by local authorities in China, together with 15754 online comments, were collected, reviewed and analyzed. The results and lessons learned from this study will be of interest and importance to city governors, service providers, IT practitioners and researchers who are engaged with smart city development in China and worldwide.

2. OVERVIEW OF LITERATURE ON SMART CITY AND MOBILE APPLICATION

This section presents the current state of research for both smart city and mobile application fields. This critical review followed the funneled approach proposed by Saunders et al. (2003, pp. 44-50), using keyword searches (e.g. smart city, eco-city, smart technology, smart application, mobile application, mobile service, and smart city app) in a number of databases (e.g. Web of Science, Engineering Index, ScienceDirect, Emerald, Google Scholar, and ProQuest), as well as tracking forward and backward citations of identified papers.

2.1. Smart City

Smart city is a complicated and multifaceted concept. Technically, it involves the deployment and usage of a set of information and communication technologies, such as Internet of Things (IoT), sensors, cloud computing, big data analytics, mobile devices, and end-user apps (Nam and Pardo, 2011). Further to technological elements, the realization of any smart city vision needs to consider a wide range of socio-technical factors, such as citizen engagement, local policies, legal regulations, existing facilities, economic situation, and even natural environment (Peng et al., 2017; Chourabi et al., 2012).

Owing to this multifaceted nature, smart city becomes a truly multidisciplinary subject that attracts the interests of researchers from many different areas, including computer sciences, telecommunication engineering, electronic and electrical engineering, urban planning, public management, political sciences, environmental studies, and information sciences, etc. In light of this discussion, an extensive

review of the literature showed that current studies on smart cities could be broadly divided into three strands (as further summarised in Table 1):

- The first strand of smart city literature focuses primarily on technical and engineering aspects, which reflect the heavy role of technology in building smart cities. Studies in this strand covered a wide range of topics, such as IoT architecture and wireless sensor networks in smart cities (Luque-Vega et al., 2020; Minoli et al., 2017), smart city testbeds and prototype design (Sotres et al., 2017; Cardone et al., 2014), smart city simulation models (Ugljanin et al., 2020; Yamagata and Seya, 2013), and big data analytic tools and algorithms for smart cities (Li et al., 2020; Qiu et al., 2017).
- The second strand of literature reports on a mixture of urban planning, political and environmental issues of smart cities. Studies found in this strand generally aimed to define the concept, scope, services and trends of smart city from a macro level (Maestre-Gongora & Bernal, 2019; Kiritmat et al., 2020), establish appropriate policies and plans for smart city development (Caragliu and Del Bo, 2019; Angelidou, 2017), measure the performance of smart cities with diverse indicators (Pinna et al., 2017; Li et al., 2020), and explore sustainability and environmental effects of smart cities (Aina, 2017; Haarstad and Wathne 2019).
- The third strand of literature joins up the first two strands with socio-technical angles that stress on the importance and intersection of information, technology, organization and citizens in smart cities. Research in this strand attempts to explore organizational issues in smart city development (Pereira et al., 2017a), investigate citizen perceptions and concerns about data privacy and security in smart cities (Li and Liao, 2017; Sookhak et al., 2018), understand the role of big data, data management, and open data in smart cities (Liu et al., 2017; Pereira et al., 2017b; Neves et al., 2020), and examine the usefulness, usability and acceptance of user-centric smart city services (Peng et al., 2017; Gholami et al., 2020).

After further comparison and review of the retrieved literature, it became clear that smart city research in the first and second strands has been very rich. In contrast, the number of journal articles in the third strand has been increasing in recent years but still seem to be limited. In fact, current articles in the third strand (e.g. Yeh, 2017; Gupta and Narayan, 2020) already demonstrated that the intersection of information, technology, organization and citizens can have significant influences on large-scale deployment and usage of smart city services, but many knowledge gaps in this strand are yet to be filled. One of the knowledge gaps that should be filled urgently by socio-technical researchers is concerned with current development, challenges and usage of smart city mobile applications, as further discussed below.

2.2. Smart City Mobile Applications

Our review of the literature returned many studies investigated issues and factors affecting the design, development, and user acceptance and behavior towards mobile apps in various contexts, such as mobile games and entertainment (Wei, 2008), mobile commerce (Leavitt, 2010), mobile social network (Vatanasakdakul et al., 2020), mobile fitness and health (Baudier et al., 2020), mobile learning (Abdou and Jasimuddin, 2020), mobile banking (Mojtahed et al., 2013; Lonkani et al., 2020), and mobile government (Talukder et al., 2020; Liu et al., 2014).

However, smart city apps are rather different from other mobile applications, especially considering the fact that such apps are an integral part of a smart city solution as well as the essential window to connect smart service providers with citizens (Peng et al., 2017). Smart city apps can thus take advantage of the latest technologies and facilities (especially IoT networks and wireless sensors) embedded in the smart city ecosystem. After combining and processing various datasets provided by diverse entities, including government, citizens, IoT sensor infrastructure and other related data sources (Aguilera et al., 2016), smart city apps can offer many innovative functions and real-time

Table 1. Three strands of current research on smart city

Research Strand	Subject Areas	Key Journals	Key Topics	Example Papers
1. Technical and engineering studies	<ul style="list-style-type: none"> • Computer sciences; • Software engineering; Electronic and electrical engineering, etc. 	<i>Computer Networks;</i> <i>IEEE Systems Journal;</i> <i>IEEE Sensors Journal;</i> <i>IEEE Internet of Things Journal,</i> etc.	Smart city IoT architecture, sensors and wireless networks	Luque-Vega et al., 2020; Minoli et al., 2017;
			Smart city testbed and prototype design	Sotres et al., 2017; Cardone et al., 2014
			Smart city simulation and models	Ugljanin et al., 2020; Yamagata and Seya, 2013
			Big data and algorithms for smart cities	Qiu et al., 2017; Li et al., 2020
2. Urban and environmental studies	<ul style="list-style-type: none"> • Urban planning; • Public management; • Political sciences; • Environmental sciences, etc. 	<i>Cities;</i> <i>Journal of Urban Technology;</i> <i>Technological Forecasting and Social Change;</i> <i>Sustainability;</i> <i>Energy policy,</i> etc.	Defining the scope, concept, services and trends of smart cities	Maestre-Gongora & Bernal, 2019; Kiritmat et al., 2020
			Smart city measurement and evaluation	Pinna et al., 2017; Li et al., 2020
			Smart city policies and plans	Angelidou, 2017; Caragliu and Del Bo, 2019
			Sustainability and environmental effects of smart cities	Aina, 2017; Haarstad and Wathne 2019
3. Socio-technical studies	<ul style="list-style-type: none"> • Information sciences; • Information system; • Urban technology, etc. 	<i>Government Information Quarterly;</i> <i>Social Science Computer Review;</i> <i>Journal of Urban Technology;</i> <i>Knowledge and Information Systems,</i> etc.	Organizational issues in smart city development	Pereira et al., 2017a
			Privacy and security issues and provisions in smart cities	Li and Liao, 2017; Sookhak et al., 2018
			The role of big data, data management, and open data in smart cities	Liu et al., 2017; Pereira et al., 2017b; Neves et al., 2020
			Usefulness and usability of smart city technologies and services	Peng et al., 2017; Yeh, 2017; Cledou et al., 2017; Gholami et al., 2020

services that go beyond the technical limitations of conventional mobile apps, such as providing real-time availability of parking spaces and showing instant bus arrival time, etc (Peng et al., 2017; Giuffrè et al., 2012).

Surprisingly, and despite their unique nature and importance towards realizing the smart vision, there is a significant scarcity of studies focusing on smart city apps. Our extensive review of the literature only returned a small number of related articles (e.g. Giuffrè et al., 2012; Aguilera et al., 2016; Delmastro et al., 2016; Bagloee et al., 2017; Peng et al., 2017), which discussed the prototype design, technical features or usage issues of some specific smart city apps. Nevertheless, it was very rare to retrieve articles to investigate and offer a holistic view on current development patterns, challenges and usage of smart city apps in a particular city and even country. We feel that an in-depth research on one specific smart city app can provide useful insights and lessons, but a holistic study of common trends, functions and issues of smart city apps available in a given city and/or country will

probably lead to more significant findings to guide future policy making, city planning, and technical development. Such holistic study is particularly needed in the Chinese context, considering China's smart city initiatives and market size, as well as the rapidly increasing number of smart city apps emerging in hundreds of Chinese cities. Therefore, we consider this study (as the first of its type in the Chinese context) to be both timely and significant.

3. METHODOLOGY

3.1 Desktop Survey of Official Smart City Apps in China

For the purpose of this study, the researchers focused exclusively on official smart city apps initiated by local authorities in China (excluding smart apps developed by private companies, like Uber), and so hoped to shed light on the latest development resulted from the government's national smart city initiatives. Considering the large number of smart city apps available in China, the researchers adopted a desktop survey approach by collecting data from app stores rather than from physical investigation of individuals. This desktop survey involved the collection of both quantitative and qualitative data to form the profile of each retrieved smart city app. In terms of quantitative data, the survey focused on aspects including app name, application area, main functions, city, province, region, user rating and numbers of user comments. In terms of qualitative data, the survey particularly focused on online textual comments left by users, with the aim of identifying potential problems and deficiencies of the retrieved app.

3.2 Data Collection Process

Although no fieldwork was conducted, the data collection process of this desktop survey was still not easy. In particular, China has 672 cities, which have rather unbalanced development. It was found very difficult and time consuming to search for suitable smart city apps across all Chinese cities without a clearer focus. In order to overcome this challenge, the researchers retrieved the Sixth China Smart City Development Assessment Report published by Govmade (a well-known domestic consulting company). This report identified 201 Chinese cities that had engaged in the smart city journey (i.e. had launched clear smart city development plan and/or had started related pilot projects), and assessed their performance from six dimensions, namely smart infrastructure, smart governance, smart living, smart economy, smart citizens, and security system (full report available in Chinese at: <http://www.echinagov.com/report/53667.htm>). The city list offered in the report helped the researchers to refine and narrow the scope of this desktop survey (i.e. from all cities in the country to the 201 smart cities identified).

Furthermore, there are many app stores available in the Chinese market (e.g. iTunes App Store for iOS users; Baidu Mobile Assistant, 360 Mobile Assistant, and Tencent App store for Android users). Different app stores contained different user comments and separated ratings toward the same smart city app, and so making it difficult to gather a holistic profile for the city apps concerned. In order to overcome this issue, the researchers identified a domestic mobile data mining and analysis tool, called Qimai (<https://www.qimai.cn/>). This tool offered a highly integrated and one-stop online platform that allowed the researchers to retrieve all related information of a given app, without the hazard of going through the various iOS and Android app stores.

Subsequently, the research team searched for suitable smart city apps in the Qimai platform by using Chinese keywords like “智慧” (the Chinese characters of “smart”, pronounced *zhìhui*), plus various application areas (e.g. transportation, parking, bus, bike sharing, health, hospital, energy, public administration, etc) and the names of the 201 identified smart cities. In order to enhance the quality of data, smart city apps were selected based on three criteria: 1) it should be initiated by local authorities in one of the 201 cities; 2) it should contain some real-time and dynamic functions and be an integral part of a smart city solution; 3) it should have a considerable number of downloads

and user comments. This effort led to the identification of 333 official smart city apps. For each identified app, a comprehensive set of quantitative and qualitative data (as mentioned in section 3.1) was collected. These 333 official smart city apps were found in 140 different cities across 30 provinces in China. The collected datasets also included 15754 textual user comments (i.e. 47 comments per app in average). The datasets were then analyzed by using three layers of quantitative and qualitative methods, as further presented and discussed in the following finding sections.

4. DATA ANALYSIS AND RESULTS

4.1 Quantitative Analysis and Results on China's Smart City Apps

The researchers processed and analyzed the collected quantitative data by using a number of statistical tools (e.g. means, frequencies, ANOVA, and Pearson's correlation) in IBM SPSS. This led to some interesting and informative findings to show regional distribution, functions and application areas, and user satisfaction rates of China's official smart city apps.

4.1.1 Regional Distribution of Smart City Apps in China

In geographical terms, 333 smart city apps were found in 140 Chinese cities covering 26 provinces and 4 municipalities. As shown in Table 2, these cities, provinces and municipalities were further aggregated into two categories, namely coastal regions (App No. = 201, 60.36%) and inland regions (App No. = 132, 39.64%). In fact, it is widely acknowledged that China has unbalanced economic development. Its coastal regions are historically more developed than inland regions, and constantly accounted for nearly 60% of the country's total GDP (He et al., 2014). Considering these economic facts, the researchers proposed two hypotheses in relation to smart city development, namely *H1: a region's smart city app number is positively related to its local GDP*, and *H2: the average number of smart city apps launched by coastal regions is higher than that of inland regions*. Pearson's Correlation was used to test H1. The results shown in Table 2 confirmed that the variables of 'Provincial GDP' and 'No. of apps' were positively related with a strong Pearson's correlation coefficient of $r = .857$ ($p < .001$). Therefore, H1 is strongly supported. A further ANOVA test was carried out to compare the means of app numbers between coastal and inland regions. Although there are a few exceptional cases (e.g. Anhui as an inland province has a good number of apps), the results confirmed H2 by indicating that the average number of smart city apps in coastal regions reached 20, which was significantly higher than the average app number (i.e. 6.6) of inland regions ($p = .002$).

4.1.2 Functionalities and Application Areas of Smart City Apps in China

On the other hand, and in terms of usage context and functions, the 333 smart city apps identified across different Chinese cities and regions seemed to maintain high level of consistency and similarity. In particular, based on their functionalities, the researchers could easily classify the identified smart city apps into three main application areas, namely smart transportation, smart healthcare, and smart livelihood (as shown in Table 3). Apps in the smart transportation area ($n=148$, 44.4%) contained functions for citizens to check traffic conditions, bus arrival times, or parking availability in real-time. Smart health apps ($n=59$, 17.7%) offered functions like mobile medical appointment, electronic medical record, pocket doctor, and predictive alerts of potential public diseases based on big data analysis. Smart livelihood apps ($n=126$, 37.8%) provided a wide range of mobile government services and neighborhood services, together with some add-on functions from the health and transportation categories. These results seemed to suggest that transportation, healthcare and livelihood are currently the top prioritized areas in the smart city development agenda of both national and local governments in China.

Table 2. Regional distribution of identified smart city apps in China

Type	Province or Municipality (M)	Representative cities	Provincial GDP *	No. of apps	% of apps	Total No. of apps	Total % of apps
Coastal regions	Jiangsu	Nanjing, Suzhou	92595.40	46	13.81	201	60.36
	Shandong	Jinan, Qingdao	76469.70	40	12.01		
	Zhejiang	Hangzhou, Ningbo	56197.00	39	11.71		
	Guangdong	Guangzhou, Shenzhen	97277.77	29	8.71		
	Fujian	Fuzhou, Xiamen	35804.04	13	3.90		
	Hebei	Shijiazhuang	36010.30	13	3.90		
	Liaoning	Shenyang, Dalian	25315.40	9	2.70		
	Guangxi	Nanning	20352.51	6	1.80		
	Shanghai (M)	--	32679.87	3	0.90		
	Tianjin (M)	--	18809.64	3	0.90		
Inland regions	Anhui	Hefei	30006.80	22	6.61	132	39.64
	Sichuan	Chengdu	40678.10	14	4.20		
	Hunan	Changsha	36425.78	12	3.60		
	Henan	Zhengzhou	48055.90	9	2.70		
	Jiangxi	Nanchang	21984.80	7	2.10		
	Inner Mongolia	Huhot	17289.20	7	2.10		
	Shaanxi	Xi'an	24438.30	7	2.10		
	Xinjiang	Urumqi	12199.08	7	2.10		
	Guizhou	Guiyang	14806.45	6	1.80		
	Hubei	Wuhan	39366.60	6	1.80		
	Gansu	Lanzhou	8246.10	5	1.50		
	Shanxi	Taiyuan	16818.11	5	1.50		
	Hainan	Haikou, Sanya	4832.05	4	1.20		
	Jilin	Changchun	15074.62	4	1.20		
	Chongqing (M)	--	20362.20	4	1.20		
	Beijing (M)	--	30320.00	3	0.90		
	Ningxia	Yinchuan	3705.18	3	0.90		
	Yunnan	Kunming	17881.10	3	0.90		
	Heilongjiang	Harbin	16361.60	2	0.60		
	Qinghai	Xining	2865.23	2	0.60		
Total	30		913228.83	333	100	333	100
Pearson's Correlation (Local GDP VS. App No.)		No. of regions	Correlation Coefficient		P		
		30	.857***		.000		
ANOVA Test (To compare means of app numbers between coastal and inland regions)		No. of regions	Total app No.	Ave. app No.	S.D.	F	P
		Coastal	10	201	20.1	11.330	.002
		Inland	20	132	6.6	5.665	

Type

* Unit= 100 million RMB, GDP in 2018, retrieved from the China Statistical Yearbook 2019

4.1.3 User Satisfaction Rates of Smart City Apps in China

Although hundreds of smart city apps were identified across China, further analysis of the data showed that current user satisfaction rates of these apps were not high. As shown in Table 4, the average user rating of the 333 smart city apps only reached 2.99 (min=1, max=5). More importantly, and as discussed above, China's coastal regions had invested heavily in smart city and produced many more smart city apps than inland regions in average. However, the results in Table 4 showed that app ratings offered by users in coastal regions were not high (i.e. 2.90 in average), and in fact were even slightly lower than the average rating of inland regions (i.e. 3.13). The histogram in Figure 1 showed this more clearly, e.g. coastal provinces like Jiangsu, Shandong and Zhejiang with high numbers of smart city apps had average ratings below 3, whereas inland provinces like Yunnan and Xinjiang had high ratings closed to 4. In other words, it is evident from our results that, for China's smart city apps, quantity does not necessarily lead to quality. The next step of the research was to explore reasons and problems affecting the quality of these smart city apps by analyzing the textual user comments collected, as further discussed below.

4.2 Qualitative Content Analysis and Results on Problems of China's Smart City Apps

Bearing in mind the above quantitative findings, the researchers carried out a qualitative content analysis to process and explore the 15754 user comments collected from app stores, with the aim of identifying and investigating deficiencies and problems currently existed in China's smart city apps.

4.2.1 The Process of Qualitative Content Analysis

In social sciences, qualitative content analysis is one of the most widely used techniques to analyze textual data (Morgan, 1993). This approach is particularly suitable when existing theory or literature on a phenomenon (e.g. problems of China's smart city apps) is limited (Hsieh and Shannon, 2005). By following the guidelines given by Hsieh and Shannon, the researchers firstly read through the collected user comments to get familiar with the dataset and obtain a sense of the whole. Subsequently, the researchers started the coding process by focusing on a subset of 626 user comments collected for 9 selected and representative smart city apps (i.e. 3 apps with the highest number of user comments for each of the three application areas). The researchers read these 626 user comments word-by-word to derive codes, which captured key user thoughts or concepts regarding issues and deficiencies existing in the 9 selected smart city apps. An initial coding scheme with quotations was then established and used as a tool to facilitate constant comparison. Next, the researchers read and re-read the remaining dataset (i.e. the rest 15128 comments for the other 324 apps) with the aim of extracting more evidence, text and quotations to the codes. During this process, some new codes emerged, and some established codes were deleted, merged or split, as appropriate. The different codes were then linked and grouped into meaningful categories or clusters. Consequently, 6 clusters of critical problems were found in China's smart city apps, namely:

- Overcomplicated and irrational app design
- Failure to meet essential and personalized needs of citizens
- Technical bugs that lead to frequent system crash
- Inaccurate information provided by smart city apps
- Poor quality of city services obtained through apps
- Lack of actual data and system integration

These 6 clusters of critical problems are common in the different types of identified smart city apps, and are discussed in details below with support of selected quotations/examples and relevant literature.

Table 3. Application areas and functions of official smart city apps in China

Category	ID	Key Functions and Services	Description	App Examples
Smart Transportation Apps (n= 148; 44.4%)	1	Real-time traffic condition reporting and route planner	Report real-time traffic information (including road closure, construction, accidents), and recommend suitable traffic routes to drivers.	Ningbotong* (www.nbtong.com.cn/) Hexingtong (http://www.zjt.gov.cn/art/2014/11/6/art_18_735380.html)
	2	Real-time public transport searcher	Citizens can check stop locations and real-time running schedules of nearby public transports (e.g. buses, subways, trams, and bikes).	
	3	Real-time parking search and reservation	Search for parking locations, get real-time availability of parking spaces, reserve empty spaces in advance, and pay for parking fees.	
	4	Traffic violations reporting and push notifications	Drivers can receive auto notifications when they get fined due to traffic violations, and can also report cases of traffic violations of other drivers.	
	5	Add-on traffic services	Citizens can use the app to top up public traffic cards, search for nearby petrol stations, and make appointments to renew driving license, etc.	
Smart Health Apps (n= 59; 17.7%)	1	Mobile hospital services	Citizens can make appointments with chosen doctors in a specific time slot, and pay for diagnosis, treatment, and medicine costs.	Hangzhou Smart Medical Care (http://wsjsw.hangzhou.gov.cn/zwdt/44046.jhtml) Health Jiaxing (http://www.jiaxing.gov.cn/jgjt/gzdt_7865/qtywxx_7869/201602/t20160219_572611.html)
	2	Electronic medical record	Citizens' original records of medical diagnosis and treatment are stored electronically and can be accessed through the app.	
	3	Pocket doctor	Citizens firstly answer "yes" and "no" questions about a current health condition, and then are given a preliminary diagnosis by the app, and even receive online advices from doctors.	
	4	Public disease prevention and alerts	Carry out big data analysis of local citizen usage records to predict potential sources of public diseases, and send citizens advice and alerts for disease prevention.	
	5	Add-on health and medical services	Citizens can use the app to receive results of physical check-up, check for hospital bed availability, and search for opening time and directions of local hospitals, etc.	
Smart Livelihood Apps (n= 126; 37.8%)	1	AR city navigation	Include augmented reality features along with native city map. When a route is selected, citizens can hold the device up at a specific part of the city, local Points of Interest (e.g. nearby shops, restaurants, and other local amenities) will then be displayed on the screen.	Smart Xiaoshan (http://www.xiaoshan.gov.cn/art/2015/4/27/art_1313942_6613938.html) Smart Kunshan (http://www.uzzf.com/ios/268942.html) * Please note, the websites given above are all in Chinese
	2	Mobile government services	A wide range of government administration services can be accessed through the app, such as checking balance and details of social insurance, making appointments with city administration departments (e.g. passport or ID card applications), tracking progress of applications	
	3	Smart neighborhood services	Pay for utility bills and property management fees, get push notifications on neighborhood activities and news, search for nearby housekeeping services, and remotely control the entry system of building hall, etc.	
	4	Integrated add-on health and transportation services	Make appointments with doctors in chosen hospitals, check direction and opening time of local hospitals, top up traffic cards, real-time public bus searcher, real-time traffic condition checking, real-time parking search, etc.	

Table 4. Means of app user ratings

Region	Application area	N	Mean	N	Mean	S.D.
Coastal regions	Smart transportation	93	2.77	201	2.90	1.157
	Smart healthcare	37	2.88			
	Smart livelihood	71	3.08			
Inland regions	Smart transportation	55	2.76	132	3.13	1.095
	Smart healthcare	22	3.09			
	Smart livelihood	55	3.54			
Overall average (Min=1; Max=5)				333	2.99	1.124

4.2.2 Overcomplicated and Irrational App Design

It is argued in the literature that simplicity and ease of use are the essential characteristics of any successful mobile applications (Charland and Lerous, 2011). Cardone et al (2013) echoed that, only apps with concise, simple and clear designs could bring in good user experience and keep users satisfied. However, the results of our content analysis showed that not all smart city apps in China were designed in such a user-friendly way. In particular, users complained that the interfaces of some apps were “too complicated” and even “confusing”. Some developers seemed to “put too many contents and functions in the app without a clear hierarchy or logical structure” (User of ST App 12). Citizens thus found it “hard and time consuming to understand how these apps work” (User of SH App 32). Overall, a considerable number of citizens cogently concluded that smart city apps with overcomplicated and irrational designs would “neither bring people convenience nor improve the quality of their busy city lives” (User of SL App 72).

Figure 1. Average app ratings in provinces

4.2.3 Failure to Meet Essential and Personalized Needs of Citizens

Researchers in the field (e.g. Lee and Lee, 2014; Yeh, 2017; Peng et al., 2017) often highlight that smart cities in general and smart apps in particular should provide user-centric functions and services to meet the needs of citizens. However, our content analysis identified a lot of examples and evidence to indicate that the requirements of citizens had not always been thoroughly considered and met by smart city apps in China. For instance, citizens complained that “there were no alternative methods to make mobile payments” (User of ST App 139), they “cannot create and store personal travel routes” (User of ST App 24), and “medical push notifications did not suit personal situation and needs” (User of SH App 4 8). Such issues will inevitably reduce usefulness and usability of smart city apps and can also lead to user dissatisfaction (Peng et al., 2017).

4.2.4 Technical Bugs that Lead to Frequent System Crash

The analysis of the collected users comments showed that, many technical bugs seemed to exist in a considerable number of smart city apps, which thus crashed frequently. Unexpected crashes of smart city apps will not just bring unnecessary hazards to users, but can also lead to data and even financial losses. For instance, some smart transportation apps might just quit automatically, when users tried to “upload photocopy of driving license” (User of ST App 146), “search for bus arrival time” (User of ST App 9), or “top up traffic cards” (User of ST App 62). In other cases with smart health apps, the smartphone screen just became white, when citizens attempted to “login to a medical account” (User of SH App 37), “pay for medical fee” (User of SH App 15), or “search for available doctor appointments” (User of SH App 25). In the context of smart livelihood, citizens complained that when paying for utility bills, some apps might “just keep loading forever” (User of SL App 114). As such, “all data entered to the app will be gone...[and sometimes] personal bank account has been charged but the bill has not been actually paid” (User of SL App 72).

4.2.5 Inaccurate Information Provided by Smart City Apps

In the smart city ecosystem, the accuracy and quality of information provided by mobile apps will be crucial to realize the intended purposes and benefits of smart solutions (Peng et al., 2017). However, our findings showed that information provided by smart city apps in China were not always accurate and sometimes could be very misleading. For example, users complained that some smart transportation apps provided “incorrect location information on parking spaces or inaccurate bus arrival time” (User of ST App 46), and so causing unnecessary time loss in their journey. On the other hand, smart healthcare apps allow citizens to find their preferred doctors at all local hospitals by conditions and specialties and then book an online appointment, but “medical specialties of doctors might be misreported in the system and their availability were often not updated in real-time” (User of SH App 16). Such problems were also found in smart livelihood apps, which offered similar health and transportation add-on services.

4.2.6 Poor Quality of City Services Obtained Through Apps

Service quality of smart city apps refers to their capability of meeting users’ personal service demands, such as system responding time and problem solving efficiency. In the smart city ecosystem, city apps will not just link citizens with sensor infrastructure, but will also act as the intermediary between citizens and service providers (e.g. government admission departments, hospitals, bus companies, and utility companies). However, it emerged from our data that, the quality of city services obtained through these apps might not always be guaranteed. For example, the “pocket doctor” function of smart health apps can allow citizens to seek online advices from hospital doctors regarding a current health condition. Nevertheless, many citizens complained that when they tried to use this function, they either “received no reply from the other side” (User of SH App 23) or “got a very simple answer from someone who apparently had very limited clinical experience” (User of SH App 41). Similar

circumstances were also identified with the usage of smart livelihood apps, from which citizens received “no reply from government admission departments when making online inquiries (User of SL App 131).

4.2.7 Lack of Actual Data and System Integration

In order to avoid having too many different apps that cause inconvenience to citizens, there is an increasing trend for Chinese cities to integrate the different existing smart city apps into a one-stop application. This attempt is evident from the extensive list of functions and features of smart livelihood apps (as detailed in Table 3 in section 4.1.2), which also contain integrated add-on services from the health and transportation categories. The ultimate aim is that, by integrating these apps and related user data into a single platform, local authorities can perform more meaningful big data analysis and offer highly innovative services to citizens (e.g. predict potential sources of public diseases and send citizens advanced alerts/advice for disease prevention). However, results of our content analysis showed that this endeavor is still in a very early stage. Specifically, and as highlighted by citizens, when they tried to use add-on health or transportation services (e.g. searching for bus arrival time) contained in smart livelihood apps, “an alternative app (e.g. a smart bus app) would just pop up” (User of SL App 133), or even worse “the system might simply point users to the webpage of the related service provider, such as bus company” (User of SL App 25). In other words, although these smart city apps seem to offer a wide range of functions and services, many of these embedded components have not been truly integrated together.

4.3 Quantification of Critical Problems Existed in China’s Smart City Apps

The last stage of our data analysis aimed to provide further validation of the 6 crucial problems identified in China’s smart city apps and also offered a quantitative view that complemented the qualitative findings presented in the previous sections. This last stage followed a quantitative content analysis approach proposed by Morgan (1993), and contained four systematic steps:

- 1) Started from the first smart city app in the list and re-read its collected user comments;
- 2) Confirmed whether or not the above 6 problems existed in this app (when a given problem was mentioned in over 10% of the user comments, we considered this as a noticeable issue for the app and so marked down “Yes”);
- 3) Repeated step 1 and 2 for all of the 333 identified apps;
- 4) Calculated the frequencies of occurrence of the 6 crucial problems in the identified smart city apps.

The results shown in Figure 2 confirmed that, the 6 identified problems occurred frequently in China’s smart city apps across all the three application areas. Among these, ‘technical bug’ was the most common problem found in almost 56% (i.e. 186 out of 333) of the retrieved apps, followed by ‘failure to meet essential and personalized needs of citizens’ (43.9%), ‘poor quality of city services obtained through apps’ (32.4%) and ‘lack of actual data and system integration’ (27.9%). The remaining two identified problems (i.e. ‘inaccurate information’ and ‘overcomplicated and irrational design’) were found in a smaller but still significant number (i.e. 16.8% and 11.1% respectively) of smart city apps. Overall, it is clear that, the identified app problems will need to be addressed urgently, in order for China to achieve its nationwide smart city initiative.

5. FURTHER DISCUSSION AND LESSONS LEARNED

The quantitative and qualitative findings derived from the desktop survey provide clear answers about current development patterns of official smart city apps in China as well as their problems and

Figure 2. Frequency of occurrence of the identified app problems in China

deficiencies. Based on these findings, the researchers identified a number of important lessons, which should be shared with and learned by government leaders, service providers, and fellow researchers of smart city in not just China but in fact worldwide:

- Our study echoed the findings of existing literature (e.g. Peng et al., 2017) and confirmed that although end-user apps may only account for a small percentage of smart city investment, local authorities cannot underestimate their importance towards the success of smart city development. In particular, and as discussed and illustrated above, city apps will serve as the intermediary that connects citizens with sensor infrastructure as well as service providers in the smart city ecosystem. In this context, regardless the heavy investment made in the infrastructure level, if the associated city app has not been designed, developed and maintained properly, the implemented smart city solution will not be able to deliver its intended benefits. Therefore, the strategic role of smart city apps should be fully recognized and acknowledged by local authorities and service providers.
- In light of the above discussion, the intermediate nature of smart city apps determines that critical problems affecting their performance are not just related to technical aspects of the app itself. As clearly identified in our study, further to design flaws and technical bugs of the app, socio-technical factors related to data quality, citizen requirements, and support and cooperation of service providers can substantially influence usability, output accuracy and service quality of smart city apps.
- Internationally, a smart city app initiated by local authorities is often a very specific application (e.g. smart parking, smart bus, and smart energy monitoring). This is resulting in the emergence of dozens of smart city apps, which may not always be in good quality and so lead to poor usage experience and potential usage hazards. Thus, there is an increasing trend for smart city endeavors to evolve from isolated systems to integrated city applications. However, anecdotal evidence shows that for many cities, having such an integrated smart system is still a dream yet to come true. In China, most cities have made important first steps towards building an integrated

smart city system. However, the status quo and problems encountered by Chinese cities also show that, this integration effort is never easy due to the inherent complexity of this task and the multiple parties and stakeholders involved. It is clear from our findings that, simply throwing a wide range of functions and services into a city app does not lead to the creation of a truly integrated application. Further to technical constraints, local authorities need to seek ways to resolve collaboration and data sharing barriers across all parties concerned, and so provide the necessary foundation for the development of integrated smart city systems.

- It is arguable that local authorities may sometimes simply treat smart city as a fashionable symbol and attempt to achieve only short-term results without careful planning and thorough consideration of local needs. Indeed, it can be argued that the above crucial problems identified in China's smart city apps are direct results of such short-term behaviors in the local level. This argument can be further supported by the fact that, although Chinese citizens have repetitively raised the same pitfalls and deficiencies of many smart city apps in their online comments, the situation has not been much improved. In other words, local authorities did not seem to make enough effort in long-term maintenance and continuous improvement towards the developed smart city apps. It should be highlighted that such short-term behavior is not just found in Chinese smart cities. A recent study done by Peng et al (2017) demonstrated that similar problems also occur in Western cities, like London. Therefore, the findings and lessons derived from our study could be valuable and useful beyond the Chinese context.

6. CONCLUSION, IMPLICATIONS AND FUTURE STUDIES

This paper reported on a survey study that investigated the status quo and critical problems of China's official smart city apps. The results showed that current smart city apps developed by local authorities in China constantly focused on three application areas (i.e. smart transportation, smart healthcare, and smart livelihood) with some interesting functions. However, and at the same time, the development of these Chinese city apps experienced very similar problems nationwide, especially related to functional, design, usage and service-related issues.

The main conclusions reached from our study are that, China's recent large-scale deployment of IoT infrastructure and hardware facilities is certainly not the only important task in its smart city journey, and that end-user app is a fundamental and integral part of the smart city ecosystem. Smart city apps should thus receive equal attention from local authorities, service providers, industrial partners, and academics. It is clearly demonstrated in this study that problems and deficiencies of city apps will not just reduce the value and usefulness of the entire smart city solution, but will also damage the reputation and image of local authorities and related cities. Therefore, when much effort was given to infrastructure and hardware, there is a clear need for local authorities to pay more attention to smart city apps, in order to maximize potential return of their smart city investments.

The results of this study have important contributions. In practical terms, the findings of this research can raise awareness of national and local authorities in China regarding the importance and current problems of their smart city apps. It is particularly important for local authorities to realize that quantity is not the same as quality. In fact, the findings of the study suggest that it is better to focus resources on a smaller number of smart city apps with better quality, rather than having dozens of apps with many inherent issues. We hope the findings and insights derived from this study can be used to guide continuous improvement of smart city apps, and eventually enhance the possibility of success of China's smart city initiative. In scientific terms, the literature review section on smart city (i.e. section 2.1) already constitutes a contribution in itself, by synthesizing and highlighting the three strands of current smart city research, as well as pointing out current knowledge gaps in socio-technical aspects. In addition, this is likely to be the first nationwide study focused on development pattern and critical problems of smart city apps in the Chinese context. It provides a good starting point for fellow researchers to carry out similar studies in their chosen cities and even other countries in the future.

Finally, it should be acknowledged that this study has two apparent drawbacks, which indicate the needs of improvement in future research. First, this study was done by using secondary data available in app stores. The nature of such data and source made it difficult for the researchers to carry out more in-depth analysis for the phenomenon under investigation, e.g. potential relationships between the usage of smart city apps and urban demographics in China, as well as reasons and causes behind the identified app problems. In order to carry out more holistic analysis and in-depth investigation, researchers in future studies can try to collect primary data by using interview and/or questionnaire, as well as to retrieve other secondary datasets related to local conditions (e.g. census, statistics on public facility distributions, and local news). Second, it was time-consuming to process and analyze thousands of user comments manually by using the conventional content analysis approach. In fact, text mining methods and algorithms are nowadays increasingly used to extract useful patterns and information hidden in a large amount of unstructured text, e.g. review comments, social media posts, emails, and web contents, etc. It is strongly recommended that researchers, especially social scientists, should try to develop and apply text mining skills as relevant in future research involving unstructured data.

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REFERENCES

- Abdou, D., & Jasimuddin, S. M. (2020). The Use of the UTAUT Model in the Adoption of E-Learning Technologies: An Empirical Study in France Based Banks. *Journal of Global Information Management*, 28(4), 38–51.
- Aguilera, U., López-de-Ipiña, D., & Pérez, J. (2016). Collaboration-centred cities through urban apps based on open and user-generated data. *Sensors (Basel)*, 16(7), 1022. Advance online publication. doi:10.3390/s16071022
- Aina, Y. A. (2017). Achieving smart sustainable cities with GeoICT support: The Saudi evolving smart cities. *Cities (London, England)*, 71, 49–58.
- Allwinkle, S., & Cruickshank, P. (2011). Creating smart-er cities: An overview. *Journal of Urban Technology*, 18(2), 1–16.
- Angelidou, M. (2017). The role of smart city characteristics in the plans of fifteen cities. *Journal of Urban Technology*, 24(4), 3–28.
- Bagloee, S. A., Sarvi, M., & Patriksson, M. (2017). A hybrid branch-and-bound and benders decomposition algorithm for the network design problem. *Computer-Aided Civil and Infrastructure Engineering*, 32(4), 319–343.
- Baudier, P., Ammi, C., & Wamba, S. F. (2020). Differing Perceptions of the Smartwatch by Users Within Developed Countries. *Journal of Global Information Management*, 28(4), 1–20.
- Caragliu, A., & Del Bo, C. F. (2019). Smart innovative cities: The impact of Smart City policies on urban innovation. *Technological Forecasting and Social Change*, 142, 373–383.
- Cardone, G., Cirri, A., Corradi, A., & Foschini, L. (2014). The participact mobile crowd sensing living lab: The testbed for smart cities. *IEEE Communications Magazine*, 52(10), 78–85.
- Cardone, G., Foschini, L., Bellavista, P., Corradi, A., Borcea, C., Talasila, M., & Curtmola, R. (2013). Fostering participation in smart cities: A geo-social crowdsensing platform. *IEEE Communications Magazine*, 51(6), 112–119.
- Charland, A., & Leroux, B. (2011). Mobile application development: Web vs. native. *Communications of the ACM*, 54(5), 49–53.
- Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., & Scholl, H. J. (2012). Understanding smart cities: An integrative framework. *Proceedings of the 45th Hawaii international conference on system sciences*.
- Cledou, G., Estevez, E., & Barbosa, L. S. (2018). A taxonomy for planning and designing smart mobility services. *Government Information Quarterly*, 35(1), 61–76.
- Delmastro, F., Arnaboldi, V., & Conti, M. (2016). People-centric computing and communications in smart cities. *IEEE Communications Magazine*, 54(7), 122–128.
- Gholami, R., Emrouznejad, A., Alnsour, Y., Kartal, H. B., & Veselova, J. (2020). The Impact of Smart Meter Installation on Attitude Change Towards Energy Consumption Behavior Among Northern Ireland Households. *Journal of Global Information Management*, 28(4), 21–37.
- Giuffrè, T., Siniscalchi, S. M., & Tesoriere, G. (2012). A novel architecture of parking management for smart cities. *Procedia: Social and Behavioral Sciences*, 53, 16–28.
- Gupta, B. B., & Narayan, S. (2020). A Survey on Contactless Smart Cards and Payment System: Technologies, Policies, Attacks and Countermeasures. *Journal of Global Information Management*, 28(4), 135–159.
- Haarstad, H., & Wathne, M. W. (2019). Are smart city projects catalyzing urban energy sustainability? *Energy Policy*, 129, 918–925.
- He, Q., Bertness, M., & Bruno, J. (2014). Economic development and coastal ecosystem change in China. *Scientific Reports*, 4(1), 1–9.
- Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9), 1277–1288.

- Kirimtat, A., Krejcar, O., Kertesz, A., & Tasgetiren, M. F. (2020). Future Trends and Current State of Smart City Concepts: A Survey. *IEEE Access : Practical Innovations, Open Solutions*, 8, 86448–86467.
- Leavitt, N. (2010). Payment applications make e-commerce mobile. *Computer*, 43(12), 19–22.
- Li, C., Dai, Z., Liu, X., & Sun, W. (2020). Evaluation System: Evaluation of Smart City Shareable Framework and Its Applications in China. *Sustainability*, 12(7), 2957.
- Li, D., Deng, L., & Cai, Z. (2020). Intelligent vehicle network system and smart city management based on genetic algorithms and image perception. *Mechanical Systems and Signal Processing*, 141, 106623.
- Li, Z., & Liao, Q. (2018). Economic solutions to improve cybersecurity of governments and smart cities via vulnerability markets. *Government Information Quarterly*, 35(1), 151–160.
- Liu, X., Heller, A., & Nielsen, P. S. (2017). CITIES Data: A smart city data management framework. *Knowledge and Information Systems*, 53(3), 699–722.
- Liu, Y., Li, H., Kostakos, V., Goncalves, J., Hosio, S., & Hu, F. (2014). An empirical investigation of mobile government adoption in rural China: A case study in Zhejiang province. *Government Information Quarterly*, 31(3), 432–442.
- Lonkani, R., Changchit, C., Klaus, T., & Sampet, J. (2020). A Comparative Study of Trust in Mobile Banking: An Analysis of U.S. and Thai Customers. *Journal of Global Information Management*, 28(4), 95–119.
- Luque-Vega, L. F., Michel-Torres, D. A., Lopez-Neri, E., Carlos-Mancilla, M. A., & González-Jiménez, L. E. (2020). IoT Smart Parking System Based on the Visual-Aided Smart Vehicle Presence Sensor: SPIN-V. *Sensors (Basel)*, 20(5), 1476.
- Maestre-Gongora, G. P., & Bernal, W. N. (2019). Conceptual Model of Information Technology Management for Smart Cities: SmartTICity. *Journal of Global Information Management*, 27(2), 159–175.
- Michelucci, F. C., Marco, A., & Tanda, A. (2016). Defining the role of the Smart-City manager: An analysis of responsibilities and skills. *Journal of Urban Technology*, 23(3), 23–42.
- Minoli, D., Sohraby, K., & Occhiogrosso, B. (2017). IoT considerations, requirements, and architectures for smart buildings-energy optimization and next-generation building management systems. *IEEE Internet of Things Journal*, 4(1), 269–283.
- Mojtahed, R., Nunes, J. M. B., & Peng, G. A. (2013). Probing future banking service opportunities: A study of the intention to adopt mobile banking among young UK graduates. *International Journal of Wireless and Mobile Computing*, 6(6), 544–555.
- Morgan, D. L. (1993). Qualitative content analysis: A guide to paths not taken. *Qualitative Health Research*, 3(1), 112–121.
- Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. *Proceedings of the 12th annual international digital government research conference: digital government innovation in challenging times*.
- Neves, F. T., de Castro Neto, M., & Aparicio, M. (2020). The impacts of open data initiatives on smart cities: A framework for evaluation and monitoring. *Cities (London, England)*, 106, 102860.
- Peng, G. C., & Nunes, M. (2017). Establishing an evidence-based 9D evaluation approach for ERP post-implementation. *Industrial Management & Data Systems*, 117(2), 398–424.
- Peng, G. C. A., Nunes, M. B., & Zheng, L. (2017). Impacts of low citizen awareness and usage in smart city services: The case of London's smart parking system. *Information Systems and e-Business Management*, 15(4), 845–876.
- Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017a). Increasing collaboration and participation in smart city governance: A cross-case analysis of smart city initiatives. *Information Technology for Development*, 23(3), 526–553.
- Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017b). Delivering public value through open government data initiatives in a Smart City context. *Information Systems Frontiers*, 19(2), 213–229.

- Pinna, F., Masala, F., & Garau, C. (2017). Urban policies and mobility trends in Italian smart cities. *Sustainability*, 9(4), 494.
- Qiu, T., Liu, J., Si, W., Han, M., Ning, H., & Atiquzzaman, M. (2017). A data-driven robustness algorithm for the Internet of things in smart cities. *IEEE Communications Magazine*, 55(12), 18–23.
- Saunders, M., Lewis, P., & Thornhill, A. (2003). *Research Methods for Business Students (3rd ed.)*. Pearson Education.
- Sookhak, M., Tang, H., He, Y., & Yu, F. R. (2018). Security and privacy of smart cities: A survey, research issues and challenges. *IEEE Communications Surveys and Tutorials*, 21(2), 1718–1743.
- Sotres, P., Santana, J. R., Sánchez, L., Lanza, J., & Muñoz, L. (2017). Practical lessons from the deployment and management of a smart city Internet-of-Things infrastructure: The SmartSantander testbed case. *IEEE Access : Practical Innovations, Open Solutions*, 5, 14309–14322.
- Talukder, M. S., Chiong, R., Corbitt, B. J., & Bao, Y. (2020). Critical Factors Influencing the Intention to Adopt m-Government Services by the Elderly. *Journal of Global Information Management*, 28(4), 74–94.
- Townsend, A. M. (2013). *Smart cities: big data, civic hackers, and the quest for a new utopia*. WW Norton & Company.
- Ugljanin, E., Kajan, E., Maamar, Z., Asim, M., & Burégio, V. (2020). Immersing citizens and things into smart cities: A social machine-based and data artifact-driven approach. *Computing*, ●●●, 1–20.
- Vatanasakdakul, S., Aoun, C., & Putra, Y. H. S. (2020). Social Media in Micro-Enterprises: Exploring Adoption in the Indonesian Retail Sector. *Journal of Global Information Management*, 28(3), 184–203.
- Walravens, N. (2015). Mobile city applications for Brussels citizens: Smart city trends, challenges and a reality check. *Telematics and Informatics*, 32(2), 282–299.
- Wei, R. (2008). Motivations for using the mobile phone for mass communications and entertainment. *Telematics and Informatics*, 25(1), 36–46.
- Yamagata, Y., & Seya, H. (2013). Simulating a future smart city: An integrated land use-energy model. *Applied Energy*, 112, 1466–1474.
- Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. *Government Information Quarterly*, 34(3), 556–565.

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