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Study on the Citizen Perceptions of Smart Cities in China: A Mediating Effect of Citizen Quality of Life

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Abstract: *Although there has been a significant amount of research focused on citizen-centric smart cities, most previous studies have primarily focused on urban residents' quality of life and well-being. There is limited knowledge on the perception of smart cities, particularly the views and attitudes of young digital natives from China. Using quality of life as a moderator, the objective of this study is to examine the perceptions of China's young citizens regarding smart cities. This quantitative study employed a survey methodology. The scales used in the study were derived from established scales found in the previous research literature. Due to personal and privacy issues, a randomized questionnaire survey was conducted to allow respondents to freely provide their answers and minimize potential bias caused by social desirability. Young participants invited to take part in the survey were contacted either verbally or through email and completed the survey online by using the Wen Juan Xing portal - the most commonly used and authoritative data collection service platform in China. This study found that the majority of reports from young citizens said that making smart city services would positively affect their quality of life. In addition, these youthful citizens argued that the creation of smart cities is a positive development. The perceptions of these young individuals have provided valuable data for evaluating and refining smart city development strategies, enabling city administrators and ICT companies to better engage with citizens. This facilitates the enhancement of ICT-based urban services to become more intelligent.*

Keywords: *Smart city service, Citizens' perceptions of smart city, Quality of life, Modified ECT theory*

1. Introduction

Currently, more than 50% of the world's population lives in city areas, and this ratio is steadily increasing [1]. According to projections by the United Nations, the urban population is expected to comprise approximately 68% of the world's total population by the year 2050[2]. The swift pace of urbanization has resulted in a range of urban challenges, including environmental pollution, traffic congestion, and limited availability of resources [3].

The “smart city” concept also referred to as “SC”, has recently gained traction in the realm of urban planning due to the fact that it is assumed or proved to have the capacity to solve a variety of issues brought on by increasing urbanization. According to Albino, Berardi [4]. The phrase "smart city" didn't make its debut until the 1990s, and it was initially part of a conversation on how to make use of newly emerging information and communication technology to achieve the goal of modernizing urban infrastructure.

According to the International Organization for Standardization (ISO), the scope of what constitutes “smart city services” (SCS) includes smart climate change adaptation, online government, smart mobility, public safety, smart medicine and health care, sustainable energy and resources, smart environmental protection, “community” and “home” [5]. The provision of these services can be found in every corner of the metropolitan area.

In 1992, with the primary goal of fortifying the basis of information technology, Singapore was the first country in the world to propose the idea of developing a "Smart Island" [6]. In 2008, IBM introduced the concept of a "Smarter Planet", and various governments began planning the development of Smart Cities. These plans included "I-Japan" in 2009, India's "Smart Cities" strategy in 2015, and the Hong Kong government released a Hong Kong Smart City Blueprint in 2017, proposing a series of SC initiatives and pilot projects to address city challenges such as geriatric populations and resource scarcity. In 2010, China, which is the largest developing country in the world, was the first to establish the concept of "Smart Cities" [7]. According to Yao, Huang [8], As of 2018, China has more than 500 smart cities, which will put it in front of the number for all other regions across the world and have all types of smart city service categories.

In the background of global smart city development, cities provide different dimensions of smart city services to cover all aspects of urban life for local residents. SCS is driven by advanced ICT (Information and Communication Technology) and aims to enhance the quality of life for residents, which has become a global consensus [9, 10]. The goal of SCS is not only to enhance the quality of life of its citizens but also to meet perceptions of their demands and desires for city services [11]. Consideration for the citizens' needs is crucial in the planning and provision of SCS since citizens are the users of these systems [12]. A growing number of scholars believe that meeting the needs of citizens is critical to the sustainable development of smart cities [13, 14]. According to the European Commission's definition, a smart city is "a place where digital and telecommunication technologies are used to make traditional networking and services more functional for the benefit of its residents and businesses" [15]. The public's perception of satisfaction with SCS has been an essential criterion for measuring the success of smart city development [16], making it a key focus of research [17]. Therefore, in citizen-centric Smart Cities, citizens' demands, satisfaction, and perceptions of Smart Cities have practical significance for urban managers and technology providers. However, citizens' subjective perceptions of quality of life remain relatively unexplored by the literature [9].

The Chinese government has taken a citizen-centric approach to SCS delivery [18], similar to that of the majority of nations worldwide. However, research on measuring the perceptions of Chinese citizens regarding smart cities (CPSC) has been limited thus far. To bridge this research gap, this study sought to investigate the effects of SCS as an independent variable, mediated by quality of life (QOL), on CPSC, as well as the heterogeneity of these variables among citizens. The objective is to guide the allocation of resources in urban development to enhance the sustainability of smart city services supply and smart city development in China and other economies with comparable characteristics.

2. Literature Review and Hypotheses Development

In this section, we start discussing our theory followed by research hypotheses, and mediating role of quality of life. This study is based on a user-centric design model (also known as government-to-citizen-to-government or G2C2G) guided by a citizen-centric approach [19] as well as draws on the modified ECT model [20] in order to explore the correlations and potential relationships between urban services related to smart city development, as it relates to quality of life, citizen perceptions, and frequency of smart technology use.

The G2C2G approach originated from the citizen-centered approach [19]. According to previous research, this approach advocates the construction of an ecosystem in which citizens are an indispensable part of the government's strategic design process. Therefore, the above strategies must meet the needs of citizens, but citizens themselves must also become active stakeholders in participating in and supporting government initiatives. In other words, citizens and the government should maintain a mutually supportive relationship to achieve the goal of improving the quality of life of citizens. Therefore, citizen feedback is crucial for determining the performance and success of smart city [9].

Oliver [21] proposed the expectation-confirmation theory (ECT) to define and predict customer satisfaction. Bhattacherjee [22] constructed an expectation-confirmation model based on this model, the relationship between expectations, perceived performance, expectation confirmation, and satisfaction is explained. As the most frequently employed model for analyzing user contentment with services [23]. ECT is extensively applied to analyze e-government services [24], user satisfaction with internet taxi [11], and many other smart city services, and so forth. Differences between expectation and perceived performance impact the confirmation of expectations, which according to Huang, Li [20] are integrated as expectation-perceived performance. Previous authors have done similar adjustment work and the ECT model has been modified. The detailed latent variables involved require determination based on the study city and population. It can be found that the QOL level in this study acts as the expectation-confirmation role in the ECT model, and the formation mechanism of citizens' perceived smart city is consistent with the ECT satisfaction. This study is based on the modified ECT theoretical framework of Huang, Li [20], where quality of life (expectation-perception) performance can directly influence citizens' perceived smart city (satisfaction) and can also play a mediating

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moderating role to regulate smart city services and citizens' perception of smart city.

2.1 Definition of SC and SCS

Cities are looking for tools to improve living conditions for their residents to address issues like unemployment, homelessness, social inequality, traffic congestions, pollution, disease, and violence [25, 26], which are brought on by the rapid global housing growth. Information Technology (IT) stands out among these tools. In light of this, cities can use information technology in the management to understand and design clever solutions in meeting the public and the private sector needs. In the desire to become a smart city, this observation represents the convergence of two trends: the digital revolution and the urbanization process [27].

City officials and technology-providing companies must offer citizens various SC services to establish a people-centric SC. According to Lee and Lee [28], these types of services can be roughly categorized as any ICT-based city services to meet the residents daily needs.

Based on different typological frameworks, SC services can be divided into several sub-domains as well (hereinafter referred to as "dimensions") [28]. Examples include Jeong, Moon [29] identified ten dimensions, namely smart administration, distribution, public health, medical care, and welfare; environment; crime and disaster prevention; and facilities management., Giffinger and Gudrun [30] proposed six dimensions namely smart economy, environment, people, governance, mobility, and living.

This paper's categorization of smart city services follows the methodology put forth by Chen and Chan [9], which takes into account the environment, people, lifestyle, economy, and mobility of smart cities. It is crucial to note that because there is no dominant typological framework to classify SC services [28], this classification is typically done for administrative reasons by municipal governments and varies greatly depending on the local context. The smart city categorization warrants another idea for further investigation.

2.2 Definition of QOL

Based on the research of Camboim, Zawislak [31].Cities constitute complicated ecosystems inhabited by individuals with diverse interests who can be supported to collaborate to achieve a sustainable environment and a satisfactory quality of life. According to research by Macke, Casagrande [32], the quality of life aspect can help strengthen the connection between the smart city notion and sustainability.

With regard to the topic of smart cities [33], the quality of life is becoming an increasingly important factor in the evaluation and formulation of public policy as well as the administration of geographic areas [34, 35]. The severe competition between metropolitan centers to attract investments and competent human resources, as well as the population's expanding sense of demand for quality of life has influenced decision-makers at all governmental levels, including locally, regionally, and nationally [36].

Smart city initiatives affect the quality of life of the inhabitants because they lead to citizens who are better informed, better educated, and more actively engaged [4]. A common misconception is that technology can solve issues on its own [37, 38]. This mistake can be dispelled by shifting away from a paradigm that is technocentric and toward one that embraces the "human" aspect.

In the scientific literature, there are numerous definitions of quality of life [39, 40] . Some of these definitions are discussed here. In most cases, one's level of health is highly correlated with one's quality of life, as stated by the WHOQOL [41], which was established by the World Health Organization (WHO). The World Health Organization defines an individual's quality of life as their sense of where they stand in life regarding their objectives, expectations, constraints, and social interactions, as well as their cultural background and value system. According to Skevington, Lotfy [40], the character of a person's physical health, psychological condition, level of independence, and social ties can influence their quality of life.

2.3 Definition of CPSC

Macke, Casagrande [32] explored the perception of quality of life in smart cities and the main factors that contribute to citizen satisfaction. Regular evaluations of people's perceptions of city improvements are starting to become relevant and active. Thus, smart cities will be truly and generously liveable, with creative demographics and intellectual economies, based on a thriving economy, respect for the environment and attention to society [42].

Do the expectations of citizens and urban planners coincide? Smart cities ought to enable organic connections between technological, human, and institutional resources, with new technologies propelling innovation [37]. This research explicitly focuses on the perceptions of smart city services and quality of life of Chinese citizens in China, one of the leading smart city growth countries with a comprehensive category of smart city services [20]. It is a paradigm for smart cities in the developing countries.

2.4 Smart City Services and Quality of Life

It is generally and evidently acknowledged that sustainable city development should be citizen-centered, meaning it should serve the needs of local inhabitants to improve their quality of life[26, 43].

Consequently, quality of life is a key factor in the evolution of smart cities[44]. However, because the concept of smart cities is relatively new, some research gaps exist in relation to the factors that affect quality of life. The concept of smart cities remains somewhat illusory due to their multifaceted nature, which generates enthusiasm and skepticism, according to Nilssen [45]. Based on Shen, Huang [46], few studies have examined the results of the application of policy measures in smart cities. Concerning the smart city concepts related to QOL, we highlight the studies of Camboim, Zawislak [31], Cerutti, Martins [47], Ismagilova, Hughes [48],Appio, Lima [49] , Carvalho, Costa [50], Paaso, Kushner [51], who emphasized that QOL is an essential aspect of the development of smarts cities. According to De Jong, Joss [52]and Wolfram [53], the impact of the application of smart city concept on the QOL of its citizens has not yet been adequately investigated, which is why De Guimarães, Severo [54] advocate for additional research in this area. As such, the following hypotheses were synthesised:

H1: There is a significant relationship between smart economy and CPSC.

H2: There is a significant relationship between smart mobility and CPSC

H3: There is a significant relationship between smart environment and CPSC.

H4: There is a significant relationship between smart living and CPSC.

H5: There is a significant relationship between smart people and CPSC.

2.5 Smart City Services and Citizens' Perception of Smart City

Lee and Lee [28] and [11] agree that the provision of SC services by municipalities that are centered on the needs of citizens is crucial. A growing number of empirical studies have attempted to document citizens' perceptions of SC services due to the benefits of presumed and actual SC services to citizens. Several empirical studies have investigated how specific features of SC services affect the well-being or quality of life of individuals, in terms of social structure relationships, environmental well-being, physical well-being, and community integration. For example, Macke, Casagrande [32] case study of the Brazilian city of Curitiba shows that SC services can improve the quality of life of its citizens. Clearly, it is not always feasible to delineate between perceptions and smart city services: for instance, in a study of SC in China, residents perceived SC services as safe, available, and convenient, which had a positive impact on their sense of subjective well-being[5]. This paper examines smart city services and citizens' perceptions of smart cities by playing a mediating role in the quality of life. Thus, the following hypotheses were formulated.

H6: There is a mediating effect between QOL and smart economy toward CPSC.

H7: There is a mediating effect between QOL and smart mobility toward CPSC

H8: There is a mediating effect between QOL and smart environment toward CPSC

H9: There is a mediating effect between QOL and smart living toward CPSC

H10: There is a mediating effect between QOL and smart people toward CPSC

H11: There is a significant relationship between QOL and CPSC.

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2.6 Quality of Life and Citizens' Perception of Smart Cities

According to Carvalho, Costa [50] and [55], QOL is a term used to describe settings that are conducive to citizens' perceived, subjective and emotional well-being. Previous studies have shown that, these favourable situations result from attitudes, behaviors, and emotions, which can increase socialization and result in less violence cases and an increase in alliances, support, and generosity. People become happier, healthier, friendlier, and more affectionate as a result [30, 56]. Chen and Chan [9] investigate some of the quality of life areas of smart cities and establishes their impact on residents' opinions on the evolution of a smart city centered on their needs.

The research model of this paper is shown in Figure 1.

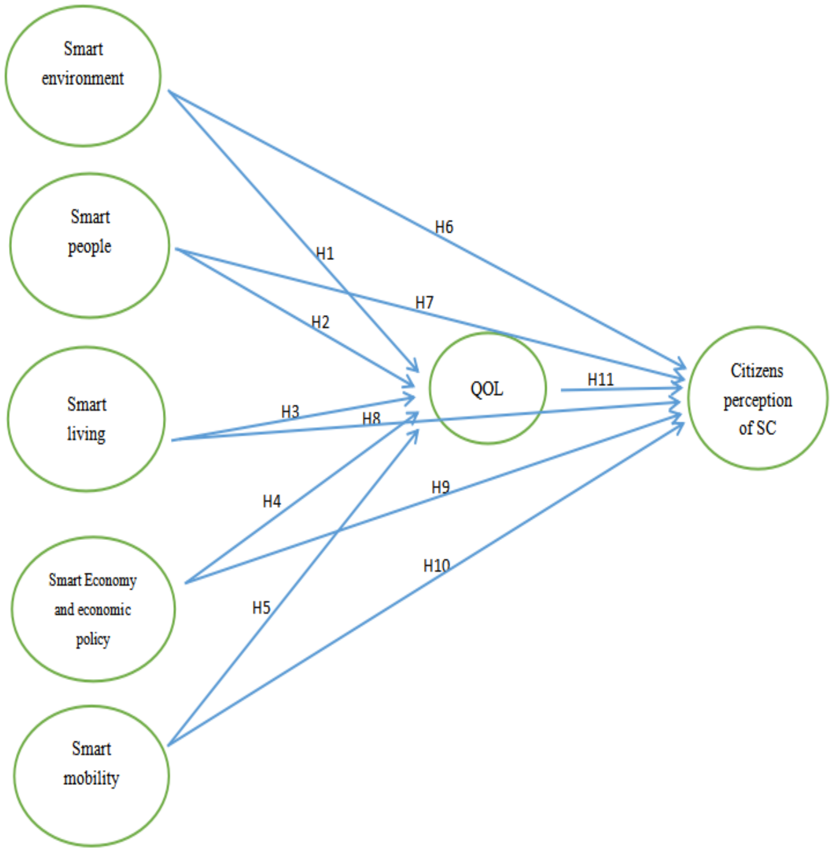

Figure 1: Research Model

3. Methodology

3.1 Study Sample

A quantitative survey was used for this study. In China, a widely recognized national data collecting service online provider called WenJuanXing which provides a wide-ranging and diverse national sample. We utilized the WenJuanXing services in June 2023 and collected data set with the advantages of reducing the sampled homogeneity and achieving better response rates. The survey was conducted in Chinese language[71]. To ensure linguistic and conceptual equivalence, a back-translation method was employed to translate these items between both the English and Chinese languages. The respondents were asked about their use of intelligent technology and other topics after getting their consent to take part in the study and we used the screening question to ensure the respondents were qualified for the survey. The measurement scales were based on previous scholars survey as shown in Table 1 below. Participants must answer all the questions in order to commit to the survey and this could avoid any missing data. Ultimately, a total of 353 valid responses were collected, examined and verified. Consequently, this study employed the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique for data analysis [70].

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Table 1: Constructs and their related studies

	Constructs	Measurement scales based on the following scholars
1	Smart environment	Kumar [57];Cook and Schmitter-Edgecombe [58]
2	Smart people	Nam and Pardo [37];Gupta, Mustafa [59]
3	Smart living	Ståhlbröst, Bergvall-Kåreborn [38];Shami, Rad [60]
4	Smart economy	Popova and Popovs [61];Turečková and Nevima [62]
5	Smart mobility	Van Audenhove, Korniichuk [63];Mataix González [64]
6	Quality of life	Chen and Chan [9];Macke, Casagrande [32];Shapiro [65]
7	Citizens' perception of smart cities	Georgiadis, Christodoulou [66];Huang, Li [20];Chen and Chan [9];[32]

(Source: Author)

3.2 Demographic Profile

In this survey conducted on young Chinese citizens, more women (53.5%) than men (46.5%) participated in the study. All respondents in the survey were under the age of 30. The largest number was between the ages of 21 and 25, an age group consisted of the majority of students. Respondents in this survey were relatively from the younger generation, with most earning less than 7,500 RMB per month. The majority of citizens in the respondents' smart cities stayed in the South, the more developed part of China. The descriptive data analysis was shown in Table 2.

Table 2: Demographic profile for respondents

Variables	N	%
Gender		
Male	164	46.5
Female	189	53.5
Age		
15 and below	29	8.3
16- 20	69	19.5
21- 25	149	42.2
26- 30	106	30
Education		
Junior high school or below	15	4.3
Senior high school	63	17.8
Bachelor	144	40.8
Master	83	23.5
Doctor	48	13.6
Monthly income		
Under 2500 RMB	13	3.7
2501 - 5000 RMB	120	34
5001 - 7500 RMB	120	34
7501 - 10000 RMB	59	16.7
Over 10000 RMB	41	11.6

(Source: Author)

4. Results

The reliability and validity tests on the constructs were established showing that all the constructs and items were reliable and valid for this study. This was shown in Table 3.

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Table 3: Validity and Reliability Test

Constructs	Cronbach's alpha	Composite reliability	AVE
cpsc	0.878	0.908	0.621
qol	0.905	0.924	0.636
s-econ	0.848	0.898	0.687
s-env	0.857	0.897	0.636
s-live	0.899	0.920	0.623
s-mob	0.857	0.903	0.700
s-ppl	0.891	0.917	0.649

SmartPLS 4 (2023) (Source: Author)

4.1 Results of Hypotheses Testing

The path coefficient will characterize the relationship between variables as determined by the bootstrapping method. The hypothesis is accepted or rejected based on the t-statistical test value. The hypothesis is accepted if the t-statistical value is greater than 1.96 (t-table) and the significance (p-value) is less than 0.05. The report of path coefficient results will appear in Table 4 as follows.

a. Direct Test

Table 4: Path Coefficient

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics	P values
qol -> cpsc	0.219	0.219	0.063	3.508	0.000
s-econ -> cpsc	0.130	0.129	0.045	2.892	0.004
s-econ -> qol	0.144	0.144	0.041	3.521	0.000
s-env -> cpsc	0.110	0.109	0.052	2.103	0.035
s-env -> qol	0.262	0.263	0.046	5.693	0.000
s-live -> cpsc	0.167	0.168	0.056	2.994	0.003
s-live -> qol	0.175	0.176	0.048	3.672	0.000
s-mob -> cpsc	0.143	0.143	0.044	3.211	0.001
s-mob -> qol	0.174	0.173	0.04	4.369	0.000
s-ppl -> cpsc	0.218	0.219	0.053	4.092	0.000
s-ppl -> qol	0.240	0.240	0.044	5.457	0.000

SmartPLS 4 (2023) (Source: Author)

b. Mediation Test

The results of hypotheses testing were shown in Table 5 below.

Table 5: Mediation Result

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics	P values	Results	VAF
s-econ -> qol -> cpsc	0.032	0.032	0.013	2.363	0.018	partial mediator	0.347
s-mob -> qol -> cpsc	0.038	0.038	0.013	2.856	0.004	no mediator	0.199
s-env -> qol -> cpsc	0.058	0.058	0.02	2.865	0.004	no mediator	0.184
s-live -> qol -> cpsc	0.038	0.038	0.015	2.486	0.013	no mediator	0.210
s-ppl -> qol -> cpsc	0.053	0.053	0.018	2.950	0.003	partial mediator	0.196

The results of the Mediation Test were shown in Table 6 below.

The results of the path analysis of this paper are shown in Figure 2.

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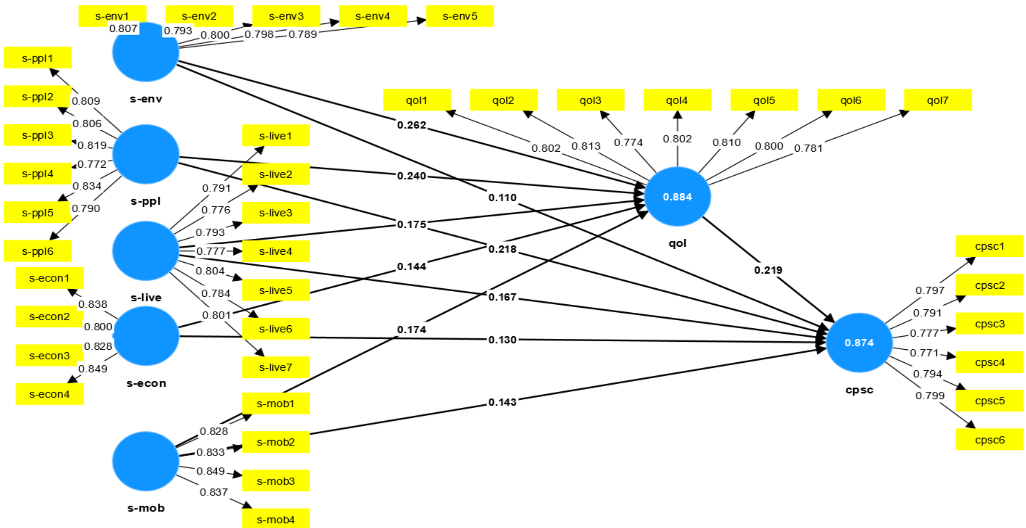
Table 6: Hypothetical Results

	Hypothesis	Results
H1	There is a significant relationship between smart economy and CPSC.	Accepted
H2	There is a significant relationship between smart mobility and CPSC.	Accepted
H3	There is a significant relationship between smart environment and CPSC.	Accepted
H4	There is a significant relationship between smart living and CPSC.	Accepted
H5	There is a significant relationship between smart people and CPSC.	Accepted
H6	There is a mediating effect between QOL and smart economy toward CPSC.	Accepted
H7	There is a mediating effect between QOL and smart mobility toward CPSC	Accepted
H8	There is a mediating effect between QOL and smart environment toward CPSC	Accepted
H9	There is a mediating effect between QOL and smart living toward CPSC	Accepted
H10	There is a mediating effect between QOL and smart people toward CPSC	Accepted
H11	QOL has a positive influence on CPSC.	Accepted



Smart PLS 4 (2023) (Source: Author)

Figure 2: Results of the path analysis

5. Discussion

The sample from China showed a high statistical fit, with an R^2 value of 0.884 for quality of life and 0.874 for citizens' perception of smart cities. All 11 hypotheses were accepted. Hypothesis 1 to 5 (H1-5), smart city services have a significant relationship to quality of life (s-econ -> qol, t-value:3.521, p-value: 0.000, s-env -> qol, t-value:5.693, p-value: 0.000. s-live -> qol, t-value:3.672, p-value: 0.000. s-mob -> qol, t-value:4.369, p-value: 0.000. (s-ppl -> qol, t-value:5.457, p-value: 0.000). Thus, this implied that smart city services in China strongly affected the level of quality of life in the city and this study validated the significant relationship between the constructs.

Hypothesis 6 to10 (H6-10), smart city services have an mediating effect toward citizens' perception of smart cities (s-econ -> cpsc, t-value:2.892, p-value: 0.004, s-env -> cpsc, t-value:2.103, p-value: 0.035, s-live -> cpsc, t- value:2.994, p-value: 0.003, s-mob -> cpsc, t-value:3.211, p-value: 0.001, s-ppl -> cpsc, t-value:4.092, p-value: 0.000). Thus, the findings suggested that there was a mediating effect between the smart city services in China and quality of life which subsequently influence the citizens' perception toward the smart city.

Hypothesis 11 (H11), there is a significant relationship between quality of life on citizens' perception of smart cities (qol -> cpsc, t-value:3.508, p-value: 0.000). Thus, this proved that quality of life in China positively affects citizens' perception of smart cities.

Variance Accounted For (VAF) is useful to determine the category of mediating variables, whether full mediation or partial mediation. If the VAF value is between 20% to 80% then it is categorized as partial mediation, however if it is above 80% then it is categorized as full mediation. Then, the VAF formula is as follows.

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VAF = Indirect Effect / (Direct Effect + Indirect Effect)

The above calculations show that the quality of life variable is classified as a partial mediator of smart environment and smart transportation since the VAF values are between 20% and 80%, i.e. 34.7% and 21%. While for smart people, smart living, smart economy and economic policy, the mediating role of quality of life is not as effective since the VAF values are 19.6%, 18.4% and 19.9%.

6. Conclusion and Recommendation

6.1 Implications

The objective of a citizen-centric smart city that offers smart city services is not just to construct smart infrastructure and technology, but also to enhance the quality of life of the residents and foster positive perceptions.

The majority of previous research focused at the quality of life, smart city services, and inhabitants' impressions of smart cities in isolation. This research added to the body of knowledge on SC by exploring the effect of SCS on citizens' views of SC through the quality of life as a mediator based on citizen-centrism, given the dearth of studies on citizens' perceptions of SC and its impact on their QOL [9].

This study assumed that SCS would cause changes in citizens' QOL, which would lead to differing perceptions of future SC, drawing on citizen-centricity techniques. Assessing SCS and its impacts on individuals' QOL can assist in determining how cost-effectively certain policy implementations will work. This input can improve how city planners and policymakers address the demands of the populace and encourage support for initiatives to construct smart cities [67].

6.2 Limitations and Future Directions

Despite the instructive results of this study, there are still some limitations that require acknowledgment. Self-reporting bias may be present in the investigations. The respondents may overestimate or underestimate their time spent using smart technology, or their quality of life level. As an emerging research area, there are many different opinions on the classification of existing smart city services. Future research should adopt more objective categories, such as the evaluation of projects such as smart governance and smart health. Moreover, this research took place in China[72]. Different personalities and social origins, as well as digital inequality, may have an effect on the results due to China's population diversity. Therefore, these considerations should be accounted for in future studies pertaining to Asia and other locations [68]. We recognize the limitations of SEM in drawing inferences about causality. [69] We suggest that future research could adopt more robust analytical instruments to test the mediating role of quality of life in determining the relationship between smart city services and citizen perceptions. This study used the modified ECT model for related design. Future studies could use longitudinal designs or experimental approaches to construct the direction of causality for these variables. It would also be interesting to try to add or replace smart city service categories in specific city cases. In addition, future research should take into account qualitative methods to understand the interaction among smart city services, quality of life, and citizens' perceptions in greater depth and detail[73].

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