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Can Smart City Development Promote Residents' Emotional Well-Being? Evidence From China

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ABSTRACT The rapid development of smart cities has raised concerns about residents' emotional well-being (EWB). To enhance EWB when developing smart cities, policy-makers should take residents' perceptions and attitudes into account. How can residents' perceptions about smart city development help promote their EWB? In this paper, we constructed a comprehensive model to explore the effect mechanism of perceived smart city developments on residents' EWB by considering the factors of stress, convenience, and life satisfaction (LS). Using a sample of 428 urban residents in a Chinese smart city, the paper verified the conceptual model by using a structural equation model (SEM) analysis. The results showed that: (1) perceived smart public service (PSPS) can increase EWB by reducing stress; it can also increase EWB by the mechanism of improved LS, brought about by this reduced stress. Perceived smart infrastructure (PSI) will reduce EWB by increasing stress; it can also decrease EWB by the mechanism of reduced LS, brought about by increased stress. (2) Perceived smart public administration (PSPA), PSPS, PSI, and perceived smart environmental protection (PSEP) can enhance EWB via the mechanism of increasing convenience and thereby improving LS. (3) Finally, the statistically insignificant relationship between convenience and LS may be due to the interaction effect of stress and convenience, because the interaction term between convenience and stress has a significant effect on LS, resulting in four insignificant indirect effects involving PSPA, PSPS, PSI, PSEP and EWB vis-à-vis convenience. Overall, this paper contributes to cross-disciplinary research on residents' perceptions with respect to smart city development, and provides guidelines for governmental policy-making in the planning of smart cities.

INDEX TERMS Perceived smart public administration, perceived smart public service, perceived smart infrastructure, perceived smart environmental protection, life satisfaction, stress, convenience, emotional well-being.

I. INTRODUCTION

Emotional well-being refers to the emotional quality of an individual's everyday experiences — the intensity and frequency of feelings such as fascination, joy, sadness, anxiety, affection, and anger that make one's life pleasant or unpleasant [1]. At present, this concept is widely used in psychology, economics, and sociology [2]–[4]. In China, with the rapid development of the Chinese economy in recent years, the material living standards of residents have greatly improved. However, this improvement of residents' economic circumstances has not necessarily led to an increase in emotional well-being [5]. A higher level of emotional well-being for residents is therefore a better measure of social development than is an economic development target *per se*. Accordingly, how to improve residents' emotional well-being should be a key issue for the government while it is working to develop the economy [6].

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Today, more than 60 percent of Chinese people live in cities. Hence improving urban design and development is an important way to improve residents' emotional well-being. Over the past decade, the term *smart city* has begun to be used more and more frequently around the world. It refers to cities that implement the latest technologies based on Internet connectivity to obtain benefits in a wide range of areas [7]. For example, ''I Shenzhen'' is an application launched by Shenzhen, China, where the well-known corporations Tencent and Huawei are located. This application uses advanced technologies such as robots, AI algorithms, and blockchain so that citizens can enjoy convenient, fast, and high-quality services related to government functions, business enterprises, and everyday life without leaving home. The basis of smart city is a combination of social capital, human capital, and information and communication technology infrastructure, all being used to achieve sustainable economic development and improve people's quality of life and well-being [8], [9]. The aim of smart cities is to improve the efficiency of urban operations, provide more effective personalized services for residents so as to meet their diverse needs, and create a better life for all. With the accelerated development of China's urbanization process, every key social indicator suggests that China is experiencing the most rapid improvement in living standards in recorded history [10]. However, in comparison with such economic objectives, the Chinese people themselves pay more attention to subjective emotional well-being, which may decline considerably even in contexts of economic improvement. For example, Brockmann *et al.* insisted that ''China experienced a massive improvement in living standards and yet people's subjective well-being fell considerably'' (P.16) [10]. Zhang *et al.* found that the poor air quality in cities is likely to reduce Chinese residents' emotional well-being [11], and Sun et. al. determined that longer commuting times decrease Chinese residents' emotional well-being by negatively affecting their overall health [12]. In short, rapid economic growth, expanding cities, and stagnant or even declining subjective well-being on the part of residents prompt us to consider the following questions: do smart cities affect residents' emotional well-being, and, if so, how?

Drawing on Chamoso *et al.*'s description of the most common characteristics of a smart city [7], we used four main dimensions to measure residents' perceptions of smart city development: perceived smart public administration (PSPA), perceived smart public service (PSPS), perceived smart infrastructure (PSI), and perceived smart environmental protection (PSEP). Smart cities may directly affect residents' lives in two ways. On the one hand, they can have a positive influence by making residents' lives more convenient [13], vis-à-vis transportation [14], health care, education, public services, and so on. On the other hand, they can have a negative influence by bringing more stress to residents' lives [15], leading to a faster pace of life, higher costs of living, more intense workloads, and so on. Furthermore, convenience and stress may affect residents' life satisfaction and their emotional well-being [16]. More precisely, the impact of different aspects of a smart city development, measured in terms of convenience, stress, and life satisfaction, will vary in their effect on residents' overall emotional well-being. This aspect of smart city development has not been discussed in previous studies. To close this research gap, the present study constructs a comprehensive model clarifying the relationships among residents' perceptions of smart city development, convenience, stress, life satisfaction and emotional well-being. The goal of this study is to investigate how residents' perceptions related to smart city development (including PSPA, PSPS, PSI, and PSEP) affect their emotional well-being through the mechanisms of stress, convenience, and life satisfaction. Developing a model to analyze these relationships, the study then tests this model empirically using data from a questionnaire distributed to residents on a large scale.

II. THEORETICAL BACKGROUND AND HYPOTHESES

A. THE IMPACT OF PERCEIVED SMART CITY DEVELOPMENT ON STRESS AND CONVENIENCE

Perceived smart city development refers to the residents' perceptions of technology-enabled intelligence with respect to public administration, services, infrastructure, and environmental protection [7]. According to theories of cognitive appraisal, when facing external environmental stimuli, individuals will respond positively or negatively through a complex, cognition-involving evaluation process [17]. Further, cognitive appraisal theory suggests that this evaluation process involves two key dimensions, namely, individual relevance and individual coping abilities [18]. Individual relevance refers to the degree to which an external stimulus is perceived as being related to an individual's life. Individual coping ability, meanwhile, refers to whether an individual is capable of coping with the external stimuli in question [16]. Considering the development of smart cities, urban residents are likely to respond based on these two dimensions of the evaluation process, potentially generating perceptions of convenience as well as stress—with stress referring to negative feelings and states generated by life events [19]. When urban residents perceive that they are not adapting to the development of smart cities, they are likely to experience a sense of stress when it comes to the dimension of individual coping abilities.

Perceived smart public administration refers to the perception that urban public administration is being intelligently handled by government, including through e-government and the management of public spaces [20], [21]. Once smart public administration establishes control, urban residents are exposed to constant surveillance [22], [23]; they may, as a result, feel as though they are being monitored and controlled, affecting how they behave and speak and reducing their freedom of speech and their potential for democratic participation [24]. In such contexts, residents will negatively evaluate smart public administration, because of the difficulty of coping with external surveillance, with their feelings of

stress thereby being increased. For its part, perceived smart public service refers to the degree of intelligence attaching to public services as perceived by urban residents, with the indicators of such intelligence typically including tele-medical services, online education, and so on. While these services bring convenience to urban residents, residents can also be overwhelmed by large amounts of information [2], [25]. Likewise, smart public services involve the collection of personal data and activity trajectories, resulting in potential privacy violations and security issues for residents [26], [27]. Hence, perceived smart public service, too, can induce stress for urban residents.

Perceived smart infrastructure refers to the perception of the smartness of urban infrastructure, including the intelligence of transportation systems, logistic systems, and hydropower systems. For example, in a variety of smart cities in China, residents can now use Alipay to finish transactions when taking a bus. Likewise, in larger cities, including Beijing, Shanghai, Hangzhou, and Guangzhou, citizens can pay with Alipay or WeChat when taking the subway. These infrastructure systems are closely related to urban residents and are a part of their daily lives. Different from their traditional living habits, smart or intelligent facilities may require urban residents to commit a large amount of time to learning about and using new technologies, while constantly updating their technical skills [28]. By the same token, smart infrastructure will record and preserve residents' personal information, possibly raising safety concerns for them [29]. Hence, smart infrastructure may result in feelings of anxiety and thereby increase stress.

Perceived smart environmental protection refers to the intelligence of the methods used for urban environmental protection, including the use of smart technologies to control pollutant emissions, engage in environmental monitoring, and facilitate garbage disposal [7], [30], [31]. For example, Beijing reduces problems with smog and increases the city's air quality by using big data techniques. That is, Beijing uses big data techniques to monitor multiple aspects of the environment, including the air quality, traffic patterns, and pollution levels. By analyzing correlations among these data, city managers can better plan their cities and protect public health. Although the perception of smart urban environmental protection can thus involve the sense of having a better living environment, PSEP may also cause certain restrictions on residents' behavior [32]—for example, by using smart devices to control the amount of garbage generated by residents, and implementing a policy of pay-per-garbage as-you-throw, meaning that residents pay a fee for generating garbage beyond a set allowance. Thus, although it is beneficial for the urban environment, smart environmental protection also limits the behavior of residents and may increase a sense of stress due to individuals' need for autonomy [33].

Based on these considerations, Hypothesis 1 was proposed.

H1. Perceived smart city development will be positively associated with stress.

H1a. Perceived smart public administration will be positively associated with stress.

H1b. Perceived smart public service will be positively associated with stress.

H1c. Perceived smart infrastructure will be positively associated with stress.

H1d. Perceived smart environmental protection will be positively associated with stress.

At the same time, although the development of smart cities can bring stress to the residents, in terms of the dimension of relevance discussed in cognitive appraisal theory, an individual is likely to make a positive evaluation when perceiving external stimuli as closely related and beneficial to themselves [15]. Along these lines, convenience refers to residents' perception that they can access urban services, via smart technology, that are flexible regarding time and location [34]. For example, Curitiba in Southern Brazil is considered to be one of the top ten smart cities in the world, and it was the first to connect the urban transportation system with a mobile phone. Commuters can purchase tickets wherever and whenever it is most convenient [9]. More generally, when urban residents perceive their city engaged in smart public administration, they sense that they can more easily and efficiently handle government-related matters [7] [35], reducing significant costs of time and energy while increasing convenience. For example, Zhejiang province, where China's well-known Internet-based company, Alibaba, is located, has launched a policy of ''just for once'' in handling the relevant public-administration procedures. The government uses cloud computing technology to acquire, collect, share, and apply public data, thereby effectively promoting the sharing of resources. Hence, urban residents can deal with government-related issues online; they no longer need to make multiple trips to government offices and are able to complete the relevant procedures via a single visit.

Further, when residents perceive that smart public services are available, urban residents can access those services remotely, engaging in online learning opportunities, for example, that would not otherwise be available due to time and space constraints [36]. Such opportunities enhance the residents' perception of convenience. For example, residents in smart cities can use the China MOOC (massive open online course), which is the largest online learning platform in China. This MOOC allows users to take courses at more than 600 universities and is flexible with respect to time and location. Likewise, smart infrastructure can help residents travel more conveniently; in having access to more efficient transportation, residents' perceptions of convenience will again be enhanced [37]. For example, the infrastructure of China's Hive Express Cabinet, which is a 24-hour self-service open platform that allows couriers using e-commerce logistics to provide the service of depositing parcels, can solve the problem of time-inconsistencies between recipients and deliveries and provide people with more convenient logistics services. Finally, smart environmental protection can provide real-time environmental information for residents through

monitoring of the environment. Such monitoring allows for the reduction of CO^2 emissions and energy consumption [38], while providing better guidance for residents' action plans and enabling people to travel based on the real-time information derived from environmental monitoring data. Such systems strengthen residents' perceptions of convenience when it comes to travel [39]. For example, through intelligent environmental monitoring, real-time fine particulate matter (PM2.5) data are provided, which makes it more convenient for people with health concerns to make decisions about travel plans.

Based on these considerations, Hypothesis 2 was proposed.

H2. Perceived smart city development will be positively associated with convenience.

H2a. Perceived smart public administration will be positively associated with convenience.

H2b. Perceived smart public service will be positively associated with convenience.

H2c. Perceived smart infrastructure will be positively associated with convenience.

H2d. Perceived smart environmental protection will be positively associated with convenience.

B. THE IMPACT OF STRESS AND CONVENIENCE ON LIFE SATISFACTION AND EMOTIONAL WELL-BEING

Subjective well-being can be categorized into three dimensions, including life satisfaction, positive affect, and negative affect [40]. Life satisfaction is a cognitive component of subjective well-being, which refers to an individual's overall evaluation of living conditions during a period of time [41]. Positive affect and negative affect are dimensions of emotional well-being, involving modes of emotional response to life events [42]. Self-determination theory holds that individuals have three basic psychological needs: competence, relationship, and autonomy. Meeting these three needs can improve subjective well-being [43].

The need for competence refers to an individual' self-confidence and sense of personal efficacy while accomplishing certain things [33]. When urban residents perceive that smart city development affords convenience rather than stress, they realize that they can handle certain matters in a manner that is flexible with respect to time and location, thereby enhancing their sense self-efficacy and meeting their competence needs [44]. Moreover, relationship needs concern interactions with others. Urban residents can have more time for interacting with others by using highly efficient smart technologies, and likewise meet others' relationship needs [45]. Thus, given that smart cities can fulfill competence and relationship needs, smart city development can improve residents' life satisfaction and emotional well-being.

Stress, by contrast, is considered a negative psychological state, and it threatens people's well-being [46]. When urban residents are unable to cope with the negative feelings generated by the requirements of adapting to new smart cities, it is difficult for them to feel self-efficacy and competence [47]. In addition, when stress increases, more time and energy are invested in managing these negative feelings, resulting in less time for interpersonal and social interactions [27]. Therefore, relationship needs are also not met. Furthermore, urban residents who perceive that they are being monitored and controlled will experience a sense of stress, because they cannot fulfill the need for autonomy. Overall, with increasing stress, the need for competence, relationship, and autonomy become more difficult to satisfy, decreasing urban residents' life satisfaction and emotional well-being [33]. In addition, Bailey *et al.* [48] and Urquijo *et al.* [49] indicate that stress undermines overall well-being. This finding reinforces the foregoing analysis..

Based on these considerations, Hypotheses 3 and 4 were proposed.

H3a. Convenience will be positively associated with life satisfaction.

H3b. Convenience will be positively associated with emotional well-being.

H4a. Stress will be negatively associated with life satisfaction.

H4b. Stress will be negatively associated with emotional well-being.

C. LIFE SATISFACTION AND EMOTIONAL WELL-BEING

Lazarus's theory of cognitive appraisal holds that an individual's cognition determines his or her emotions, meaning that emotions are the function or result of a cognitive appraisal, and cognition precedes emotions [15]. Based on this theory, this study further clarifies the relationship between life satisfaction and emotional well-being via subjective well-being. When residents perceive a higher level of life satisfaction in smart cities, this positive cognitive appraisal of living conditions increases positive emotions, thereby improving the emotional well-being of urban residents [50]. Specifically, if residents are satisfied with urban life, their perceived living conditions are better than expected [51], [52]. Such unexpected feelings tend to increase residents' positive emotional experience and improve the emotional well-being of urban residents. Furthermore, when perceived life satisfaction is high, urban residents have an optimistic attitude toward life and maintain a good mood, increasing emotional well-being.

Based on these considerations, Hypothesis 5 was proposed.

H5. Life satisfaction will be positively associated with emotional well-being.

D. THE MEDIATING EFFECT OF STRESS VS. CONVENIENCE

As H5 suggests, in keeping with cognitive appraisal theory [15], the emotional response stirred by life events is the result of a complex conceptual evaluation process. This process includes positive and negative cognitions that, lay a theoretical foundation for exploring the inner mechanism linking residents' perceptions about smart city development and their emotional well-being. In other words, perceptions of smart city development affect emotional well-being through both positive and negative paths. On the one hand, smart city

development can provide great benefits for residents, as discussed in connection with H2 and H3b [7], [27], [38], [53]. These benefits cause urban residents to feel that smart city is convenient; in turn, this perception of convenience improves their emotional well-being through the fulfillment of competence and relationship needs [43]. Hence, convenience plays the role of a mediator between perceptions of smart city development and emotional well-being.

Based on these considerations, Hypothesis 6 was proposed.

H6. Convenience mediates the effect of perceived smart city development on emotional well-being.

H6a. Convenience mediates the effect of perceived smart public administration on emotional well-being.

H6b. Convenience mediates the effect of perceived smart public service on emotional well-being.

H6c. Convenience mediates the effect of perceived smart infrastructure on emotional well-being.

H6d. Convenience mediates the effect of perceived smart environmental protection on emotional well-being.

On the other hand, as discussed in connection with H1 and H4b, although residents perceive the convenience provided by smart city development, they also perceive that such development increases the cost of living, while also affecting their expenditures of time and energy, their information security, and so forth [2], [22]–[27]. As a result, urban residents are prone to negative evaluations of smart city development, resulting in a greater sense of stress. These feelings of stress prevent or reduce the fulfillment of urban residents' competence, relationship, and autonomy needs, thereby decreasing their emotional well-being [33]. Hence, alongside convenience, stress also plays the role of a mediator between perceived smart city development and emotional well-being.

Based on these considerations, Hypothesis 7 was proposed.

H7. Stress mediates the effect of perceived smart city development on emotional well-being.

H7a. Stress mediates the effect of perceived smart public administration on emotional well-being.

H7b. Stress mediates the effect of perceived smart public service on emotional well-being.

H7c. Stress mediates the effect of perceived smart infrastructure on emotional well-being.

H7d. Stress mediates the effect of perceived smart environmental protection on emotional well-being.

E. THE MULTIPLE-MEDIATING EFFECTS OF STRESS, CONVENIENCE, AND LIFE SATISFACTION

Based on hypothesis 6 and 7, as well as the assumption by cognitive appraisal theorists that life satisfaction precedes emotional well-being [15] (see our discussion of hypothesis 5), we posit that perceptions of smart city development affect emotional well-being through a multiple-mediation effect. Specifically, when the development of smart city brings lots of benefits [7], residents can save time and effort and enjoy city goods and services efficiently [27], thus enhancing the perception of convenience. This perception of convenience will, in turn, enhance residents' perception of life satisfaction—in accordance with the assumption that cognition precedes emotion. Also, high life satisfaction implies that emotional well-being has been facilitated via meeting people's competence, autonomy, and relationship needs [33]. Hence, convenience and life satisfaction have a multiple-mediating effect vis-à-vis perceived smart city development and residents' emotional well-being.

Based on this analysis, Hypothesis 8 is proposed.

H8. Perceived smart city development will be positively associated with emotional well-being through the multiple mediators of convenience and life satisfaction.

H8a. Perceived smart public administration will be positively associated with emotional well-being through the multiple mediators of convenience and life satisfaction.

H8b. Perceived smart public service will be positively associated with emotional well-being through the multiple mediators of convenience and life satisfaction.

H8c. Perceived smart infrastructure will be positively associated with emotional well-being through the multiple mediators of convenience and life satisfaction.

H8d. Perceived smart environmental protection will be positively associated with emotional well-being through the multiple mediators of convenience and life satisfaction.

Moreover, in keeping with hypothesis 1, while smart city development brings convenience, it can also create feelings of stress for urban residents. In that case, strong feelings of stress will cause low evaluations of life satisfaction, and thus diminishing emotional well-being—due to the non-fulfillment of people's competence, autonomy, and relationship needs [33]. Therefore, stress and life satisfaction also have a multiple-mediating effect vis-à-vis perceived smart city development and residents' emotional well-being.

Based on this analysis, Hypothesis 9 is proposed.

H9. Perceived smart city development will be negatively associated with emotional well-being through the multiple mediators of stress and life satisfaction.

H9a. Perceived smart public administration will be negatively associated with emotional well-being through the multiple mediators of stress and life satisfaction.

H9b. Perceived smart public service will be negatively associated with emotional well-being through the multiple mediators of stress and life satisfaction.

H9c. Perceived smart infrastructure will be negatively associated with emotional well-being through the multiple mediators of stress and life satisfaction.

H9d. Perceived smart environmental protection will be negatively associated with emotional well-being through the multiple mediators of stress and life satisfaction.

F. THE MODERATING EFFECT OF STRESS

Although the development of smart cities brings convenience and life satisfaction to urban residents, it also causes residents feelings of stress. Based on positive and negative dual-effects, when analyzing the results of convenience and life satisfaction originating from a smart city, we should consider the

different circumstances in which residents experience stress in order to measure its effects accurately [54]. Feelings-as-information theory holds that individuals may make different evaluations based on the same cognition but under the influence of different emotional feelings [55]. Thus, when it comes to the cognition of convenience and life satisfaction, the effect results will be different according to whether residents are experiencing feelings of stress, in line with mood-as-information theory [56]. Therefore, the relationship among convenience, life satisfaction, and emotional well-being will vary dependent on stress.

Specifically, when stress is low, it has less influence on cognitive appraisal. In that case, in keeping with hypotheses 3 and 5, convenience and life satisfaction can improve emotional well-being for urban residents. Previous studies have likewise found a positive relationship between low levels of stress and well-being [57]–[59]. However, when stress is high, urban residents are less able to cope with the sense of being monitored and controlled [22], [23], concerns about personal-information leakage and privacy issues [27], and the intertwining of worklife and family life brought about by smart cities [2]. Due to high stress, urban residents will be more aware of the cost of expending time and energy to cope with smart city problems, thereby losing many opportunities for other activities. These evaluations will affect residents' perceptions of convenience and life satisfaction, and, in keeping with cognitive appraisal theory [15], residents' low perception of convenience and life satisfaction cannot enhance their emotional well-being. Thus, the relationship among convenience, life satisfaction, and emotional well-being are weakened under high stress. If the stress becomes too high, urban residents will find themselves living under extreme pressure and be unable to perceive the convenience and life satisfaction brought by smart cities. In this circumstance, convenience, as well as life satisfaction, have a negative relationship with emotional well-being.

Based on this analysis, we propose Hypothesis 10.

H10a. Stress plays a negative moderating role between convenience and emotional well-being. That is, when stress is low, convenience has a positive impact on emotional well-being. By contrast, when stress is high, convenience has a negative impact on emotional well-being.

H10b. Stress plays a negative moderating role between life satisfaction and emotional well-being. That is, when stress is low, life satisfaction has a positive impact on emotional well-being. By contrast, when stress is high, life satisfaction has a negative impact on emotional well-being.

III. METHOD

A. QUESTIONNAIRE DESIGN, SAMPLE AND DATA COLLECTION

Considering the subjective perception variables of perceived smart city developments, emotional well-being, life satisfaction, and stress, which are difficult to measure by second-hand data publicly, this study uses a questionnaire survey to collect data. The questionnaire mainly includes three parts. The first part describes the questionnaire response requirements. We were committed to respondents filling in the questionnaire anonymously and confidentially, and promised the data obtained would only be used for scientific research. In addition, respondents were encouraged to answer questions based on their own perception, as much as possible. The second part is the main content of the questionnaire, including the four dimensions of perceived smart city development, stress, convenience, life satisfaction and emotional well-being. The third part includes demographic characteristics, collecting the basic information of the respondents, including gender, age, education, income, local city household, and social insurance.

The study respondents for the formal survey were urban residents of 220 new smart cities evaluated by the China Development and Reform Commission in 2017 [27]. Data was collected during March 2018 to the end of July 2018. Considering the scattered target audience of the questionnaire, an electronic questionnaire was created used by the third-party platform ''Questionnaire Star'' (China's largest questionnaire distribution platform), and was distributed randomly throughout the country. A total of 600 questionnaires were distributed, eliminating questionnaires filled by non-smart city residents who had never used mobile payments (Alipay, WeChat, etc.) for purchase transactions, and those who were more than 5% of the items that were not answered. In the end, 428 valid questionnaires were obtained, and the effective questionnaire response rate was 71.33%. The detailed demographic characteristics of respondents were showed in Table 1.

B. MEASUREMENT

The variables of this study were measured on the basis of previous research and then translated (English to Chinese) and back-translated (Chinese to English) by two management scholars to ensure the validity of the translation in a cross-cultural setting. Specifically, the scale design includes three steps: first, a few criteria were used to select the appropriate scales, including the degree of match with the research object, the reliability and validity, and the cited frequency of the scale; second, two management scholars first translated the scale from English into Chinese and then translated the scale from Chinese into English to check the accuracy of the scale. Furthermore, by inviting smart city residents to participate in the pre-test, they were asked about their understanding of the scale items, leading to modifications to the survey structure and item-wording of the questionnaire, and to make the semantics concise and easy to understand. Table 2 depicts all the measurement items of the constructs.

To measure stress, we focused on the state of city residents' psychology in the last month. A fourteen-item scale adapted from Cohen *et al.* [60] was used to access the stress construct. The life satisfaction scale measure was accessed by five items adapted from Diener *et al.* [61], which refers to the overall perception of urban residents about their living conditions. The convenience scale measures the access of urban services

TABLE 1. Description of sample (N=428).

Profile of respondents	Class	Frequency	%
Gender	Female	206	48.1
	Male	222	51.9
Age (in years)	<30	136	31.8
	30-40	120	28.0
	40-50	118	27.6
	>50	54	12.6
Education	undergraduate student	76	17.8
	Bachelor degree	202	47.2
	Master degree or above	150	35.0
Income	100,000RMB	88	20.6
	100,000-200,000RMB	201	47.0
	200,000-300,000 RMB	80	18.7
	above 300,000 RMB	59	13.8
Local city household	Yes	133	31.1
	No	295	68.9
Social insurance	Yes	89	20.8
	No	339	79.2

for residents, using six items derived from Kaura *et al.*, [62]. The emotional well-being variable was measured using eight items to refer to the subjective emotional state of urban residents. The scale was adapted from Diener et al [42]. Perceived smart city development measures the urban residents' perception of the intellectualization of cities. These scales were designed based on Chamoso *et al.*'s [7] research, including four dimensions: perceived smart public management (five-item), perceived smart public services (four-item), perceived smart infrastructure (six-item), and perceived smart environmental protection (four-item).

C. STATISTICAL ANALYSIS TOOLS

This study was conducted with SPSS 20.0 and AMOS 23.0. to analyze the Pearson's correlation, direct effect, mediation effect (including multiple mediation), and moderation effect of stress. First, considering a covariance for structural equation model (SEM) can analyze the measurement model and structural model simultaneously [63], and it can evaluate the model fit indices, the coefficient estimation is considered more accurate. Likewise, compared with Baron&Kenny's [64] method of causal steps to test the mediation effect, the bootstrap analysis technique in Amos software using resamples can make more robust indirect effects and analyze multiple mediation [65]. Given the powerful Amos software in mediation effects test, this tool was used to test the direct and mediating effects (including multiple mediation) between latent variables. In addition, the PROCESS macro program developed by Hayes [66] based on the bootstrap's technique was executed to verify the moderation for the robust results instead of hierarchical linear regression. For bootstrap's technique, the indirect or moderation effects were considered significant if the values of bias-corrected bootstrap confidence intervals, derived from 5000 bootstrap resamples, do not include zero [67].

IV. ANALYSIS AND RESULTS

A. DESCRIPTIVE STATISTICS

The mean, standard deviation and correlations among constructs are shown in table 3. The bivariate correlation values among constructs indicated that most of the study variables had a significant relationship between each other, except for stress with service and stress with convenience, which is still suitable to empirically validate our theoretical framework and for conducting a series of structural equation modeling (SEM) analysis and to verify the moderation by PROCESS macro program as described below.

B. RELIABILITY AND VALIDITY TESTS

First, we use Cronbach's α to test the reliability of all constructs. As is shown in table 2, the values of Cronbach's α about all constructs are between 0.884 to 0.915, which meets the criterion that is greater than 0.7 [67]. Then, a confirmatory factor analysis (CFA) was used to test the reliability and validity of the constructs. The result shows that all of the standardization factor loadings are all above 0.600 and significant at the $p < .001$ level, and the composite reliability (CR) of the eight constructs is also above 0.7 [67], showing that the data has good reliability again.

In addition, except for the stress construct, the average variance extracted (AVE) values of other seven constructs are all

TABLE 2. Constructs, items, and measurement model (N=428).

Construct and items	F. L	CR	AVE	Cronbach's α
Emotional well-being（EWB）		0.911	0.562	0.910
1. I lead a purposeful and meaningful life	0.786			
2. My social relationships are supportive and rewarding	0.723			
3. I am engaged and interested in my daily activities	0.726			
4. I actively contribute to the happiness and well-being of others	0.704			
5. I am competent and capable in the activities that are important to me	0.778			
6. I am a good person and live a good life	0.751			
7. I am optimistic about my future	0.748			
8. People respect me	0.775			
Perceived smart public administration (PSPA)		0.886	0.609	0.886
1. The intellectualization level of the management of public spaces in this city is very high.	0.809			
2. The intellectualization level of the facilities management in this city is very high.	0.797			
3. The intellectualization level of the cultural heritage management in this city is very high.	0.819			
4. The popularity of e-government in this city is very high.	0.721			
5. The transparency of the government management in this city is very high.	0.752			
Perceived smart infrastructure (PSI)		0.879	0.549	0.876
1. The intellectualization level of the transport system in this city is very high.	0.793			
2. The intellectualization level of the information infrastructure in this city is very high.	0.742			
3. The intellectualization level of the electrical grid in this city is very high.	0.687			
4. The intellectualization level of the water network in this city is very high.	0.671			
5. The intellectualization level of the logistics network in this city is very high.	0.751			
6. The internet of everything is developing fast in this city	0.791			
Construct and items	F. L	CR	AVE	Cronbach's α
Perceived smart public service (PSPS)		0.836	0.561	0.835
1. The intellectualization level of public health services in this city is very high.	0.761			
2. The intellectualization level of social security in this city is very high.	0.754			
3. The popularity of digital education in this city is very high.	0.781			
4. The intellectualization level of the construction services in this city is very high.	0.698			
Perceived smart environmental protection (PSEP)		0.891	0.671	0.891
1. The intellectualization level of pollution control in this city is very high.	0.817			
2. The intellectualization level of waste management in this city is very high.	0.823			
3. The intellectualization level of the environment monitoring in this city is very high.	0.815			
4. It has a high usage of renewable energies in this city.	0.822			
Stress (STRE)		0.916	0.439	0.915
1. In the last month, how often have you been upset because of something that happened unexpectedly?	0.707			
2. In the last month, how often have you felt that you were unable to control the important things in your life?	0.654			
3. In the last month, how often have you felt nervous and "stressed"?	0.670			
4. In the last month, how often have you dealt successfully with irritating life hassles?	0.630			
5. In the last month, how often have you felt that you were effectively coping with important changes were occurring in your life?	0.669			
6. In the last month, how often have you felt confident about your ability to handle your personal problems?	0.608			
7. In the last month, how often have you felt that things were going your way?	0.661			

TABLE 2. *(Continued.)* **Constructs, items, and measurement model (N=428).**

8. In the last month, how often have you found that you could not cope with all the things that you had to do?	0.623			
9. In the last month, how often have you been able to control irritations in your life?	0.639			
10. In the last month, how often have you felt that you were on top of things?	0.679			
11. In the last month, how often have you been angered because of things that happened that were outside of your control?	0.662			
12. In the last month, how often have you found yourself thinking about things that you have to accomplish?	0.643			
13. In the last month, how often have you been able to control the way you spend your time?	0.710			
14. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0.713			
Convenience (CONV)		0.885	0.564	0.884
1. In this city, I can get any service for life with little effort.	0.751			
2. In this city, all the services for life are easy to access.	0.807			
3. In this city, making up my mind about what service for life I want to buy is easy.	0.807			
4. In this city, I can complete the purchase of my service for life easily and quickly.	0.707			
5. In this city, it is easy for me to obtain follow-up service from the provider after my purchase.	0.700			
6. Living in this city is very convenient.	0.725			
Life Satisfaction (LS)		0.889	0.616	0.885
1. In most ways my life is close to my ideal	0.847			
2. The conditions of my life are excellent	0.753			
3. I am satisfied with my life	0.804			
4. So far, I have gotten the important things I want in life	0.810			
5. If I could live my life over, I would change almost nothing.	0.702			

TABLE 3. **Descriptive statistics and Pearson's correlations (N=428).**

Constructs	1	2	3	4	5	6	7	8
1.Administration	**0.780**							
2.Infrastructure	0.334**	**0.741**						
3.Protection	0.217**	0.355**	**0.819**					
4.Service	0.187**	0.451**	0.324**	**0.749**				
5.Stress	0.153**	0.133**	0.030	-0.041	**0.663**			
6.Convenience	0.337**	0.487**	0.358**	0.389**	-0.033	**0.751**		
7.Life Satisfaction	0.172**	0.310**	0.434**	0.355**	-0.102*	0.303**	**0.785**	
8.Emotional well-being	0.258**	0.277**	0.181**	0.276**	-0.137**	0.242**	0.411**	**0.750**
Mean	4.842	5.173	4.852	5.286	4.897	4.968	5.094	4.659
SD	1.124	0.930	1.250	0.948	0.875	1.045	1.042	0.922

Squared root of the average variance extracted (AVE) values are on the diagonal.
Pearson's correlations are below the diagonal.
*Significant at 0.05. **Significant at 0.01.

above 0.5. Following Fornell & Larcker's criterion, the AVE value is ideal if it's greater than 0.50, and 0.360-0.500 belongs to the acceptable range. Hence, the AVE value of stress (0.439) is still acceptable [68]. Furthermore, the model fit indices were as follows: χ^2/df=1.335; comparative fit index (CFI)=0.962; Tucker–Lewis index (TLI)=0.959; incremental fit index (IFI)=0.962; root mean square error of approximation (RMSEA)=0.044. According to the guidelines in the literature [69], all the indices were above the minimum acceptable values, indicating an adequate fit.

TABLE 4. CFA model comparison for common method variance test (N=428).

MODEL	$\chi 2$	DF	$\Delta\chi 2$	ΔDF	P
SINGLE FACTOR	8478.021	1274	6814.321	28	0.000
MULTI-FACTOR	1663.700	1246			

The results of the discriminant validity are as follows: the AVE values on the diagonal are larger than the square of the Pearson correlation coefficient between the construct and the others, indicating that the data have good discriminant validity [68]. Likewise, this study compares the model fit indices to verify the discriminant validity of the data. The results showed that compared with the model fit indices of single factor model (EWB+PSPA+PSPS+PSI+PSEP+ STRE +CONV+LS, χ^2/df=6.759; CFI=0.338; TLI=0.311; IFI= 0.341; RMSEA=0.117), four-factor model (PSPA+ PSPS+ PSI+PSEP; STRE; CONV; EWB+LS, χ^2/df=3.664; CFI = 0.704; TLI=0.690; IFI=0.705; RMSEA=0.079), the eight-factor model fit indices are better (EWB;PSPA;PSPS; PSI; PSEP;STRE;CONV;LS. χ^2/df=1.335; CFI=0.962; TLI=0.959; IFI=0.962; RMSEA=0.044), which further illustrates that the questionnaire of this study has good discriminative validity. The above analysis results verify that the data of this study have good reliability, convergent and discriminant validity.

C. COMMON METHOD VARIANCE

Since self-reported questionnaires may cause common method variance (CMV) [70], two methods, including the design of the study's procedures and post-statistical tests, were used to control and identify method biases. On the one hand, while designing the study's procedures we promised to protect respondent anonymity and told respondents that answers are not right or wrong so that they could answer questions as honestly as possible, thus reducing evaluation apprehension [70]. Likewise, questionnaires did not show the purpose of the study, and the meaning of all constructs was removed to minimize social desirability bias. In addition, all items were distributed randomly to control retrieval cues prompted by the question context, and some items were also reversed to examine whether the respondents were responsible to answer. On the other hand, with regard to post-statistical tests, three statistical tests were used, as follows. First, Table 4 depicts the method of CFA' comparison (confirmatory factor analysis). We compared the fit of a CFA model in which all indicators loaded on one factor with the other CFA model included being eight-factor [71]. And the value of Chi-square in eight-factor CFA model is significantly better than the one factor CFA model, showing that the study was not significantly affected by common method variance. Second, following the literature of Podsakoff *et al.* [70] and Liang *et al.* [72], we included a common method factor including all of constructs' indicators and calculated average indicator's variances substantively explained by the constructs and by the common method factor (CMV). The results demonstrated that the average indicator's variances explained by the constructs is 0.486, whereas the average indicator's variances explained by CMV is 0.057. The ratio of average constructs' variance to common method factor's variance is about 8:1. In addition, most loading paths affected by common method factor are not significant. Third, Harman's one-factor test was used [73]. When all the variables in the study made an exploratory factor analysis, it showed that the first factor without rotation can only explain the variance of 30%, which is lower than the 50% criterion. Hence, given the above procedures' control design and post-statistical tests, we contend that the common method bias in the research data is not a serious concern, laying a solid foundation for further empirical tests.

D. TESTING OF HYPOTHESIZED DIRECT EFFECTS

The direct effect tests are shown in table 5 when controlling the influence of relative variables. The model drawn by covariance-based SEM using AMOS23.0 had adequate fit with the observed data, (χ2/df=1.599; CFI=0.920; TLI=0.916; IFI=0.921; RMSEA=0.037). In terms of the robust results, we generated 5000 bootstrapping samples from the original data set (N=425) by random sampling to test the paths' significance. The path is significant if the bias-corrected bootstrap confidence intervals do not include zero. First of all, the two relationships among perceived smart city development and stress are significant at 0.05, except for the two relationships between perceived smart environmental protection with stress (β=−0.016, bias-corrected 95% CI=−0.151 to 0.126, including zero, P >0.1), perceived smart public administration with stress(β=0.114, bias-corrected 95% CI=−0.029 to 0.244, including zero, P > 0.1). Compared with the negative effect between perceived smart public service and stress (β=−0.260, bias-corrected 95% CI=-0.471 to −0.077, no including zero, P < 0.05), the perceived smart infrastructure has a positive impact on stress at 0.05 significance level (β = 0.243, bias-corrected 95% CI=0.047 to 0.499, no including zero, P < 0.05). In summary, H1c was supported and H1a as well as H1d were not supported. Nevertheless, H1b was partially supported due to the adverse relationship between perceived smart public service and stress (from a negative relationship to positive).

Second, the four relationships among perceived smart city development with convenience are all positive and significant at 0.05 (all bias-corrected 95% CI are not including zero, P < 0.05). H2 (H2a-H2d) were all supported. In addition, the relationships are significant at 0.05 between convenience with life satisfaction (β = 0.356, bias-corrected

TABLE 5. Hypothesized direct effects (N=428).

hypothesized direct effects.	Coefficient	Bootstrap 5000 times bias-corrected intervals		
		95%Lower	95%Upper	P-value
Perceived smart public administration->Stress	0.114	-0.029	0.244	0.120
Perceived smart public service->Stress	-0.260	-0.471	-0.077	0.007**
Perceived smart infrastructure->Stress	0.243	0.047	0.499	0.018*
Perceived smart environmental protection->Stress	-0.016	-0.151	0.126	0.815
Perceived smart public administration->Convenience	0.154	0.039	0.272	0.011*
Perceived smart public service->Convenience	0.293	0.087	0.513	0.005**
Perceived smart infrastructure->Convenience	0.402	0.194	0.624	0.002**
Perceived smart environmental protection->Convenience	0.143	0.043	0.261	0.012*
Convenience->Life Satisfaction	0.356	0.250	0.483	0.002**
Stress->Life Satisfaction	-0.108	-0.199#	-0.020#	0.063+
Life Satisfaction->Emotional well-being	0.383	0.231	0.540	0.002**
Stress->Emotional well-being	-0.129	-0.221	-0.045	0.004**
Convenience->Emotional well-being	-0.031	-0.172	0.105	0.673

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. # bias-corrected 90% CI. The data results in bold indicate the hypothesis is significant.

TABLE 6. The indirect effect of hypothesized paths (N=428).

Paths	Estimate	Bootstrap 5000 times bias-corrected intervals		
		95%Lower	95%Upper	Significance
Administration -> Stress -> Emotional well-being	-0.015	-0.045	0.001	No
Service -> Stress -> Emotional well-being	0.034	0.008	0.080	Yes
Infrastructure -> Stress -> Emotional well-being	-0.031	-0.083	-0.006	Yes
Protection -> Stress -> Emotional well-being	0.002	-0.017	0.023	No
Administration -> Stress -> Life -> Emotional well-being	-0.005	-0.019	0.000	No
Service -> Stress -> Life -> Emotional well-being	0.011	0.001	0.032	Yes
Infrastructure -> Stress -> Life -> Emotional well-being	-0.010	-0.031	-0.001	Yes
Protection -> Stress -> Life -> Emotional well-being	0.001	-0.005	0.009	No
Administration -> Convenience -> Emotional well-being	-0.005	-0.038	0.015	No
Service -> Convenience -> Emotional well-being	-0.009	-0.066	0.029	No
Infrastructure-> Convenience -> Emotional well-being	-0.012	-0.081	0.039	No
Protection-> Convenience -> Emotional well-being	-0.004	-0.031	0.012	No
Administrations-> Convenience -> Life -> Emotional well-being	0.021	0.006	0.044	Yes
Service -> Convenience -> Life -> Emotional well-being	0.040	0.014	0.088	Yes
Infrastructure -> Convenience -> Life -> Emotional well-being	0.055	0.024	0.103	Yes
Protection -> Convenience -> Life -> Emotional well-being	0.019	0.006	0.042	Yes

95% CI=0.250 to 0.483, no including zero, $P < 0.05$) and life satisfaction with emotional well-being ($\beta = 0.383$, bias-corrected 95% CI=0.250 to 0.483, no including zero, $P < 0.05$). H3a and H5 were supported. However, the relationship between stress and emotional well-being is negatively significant at 0.05 ($\beta = -0.129$, bias-corrected 95% CI=−0.221 to −0.045, no including zero, $P < 0.05$), therefore H4b was supported. And the negative relationship between stress and life satisfaction is still significant at 0.1($\beta = -0.108$, bias-corrected 90% CI=−0.221 to −0.045, no including zero, $P < 0.1$). H4a was still supported. Whereas the relationship between convenience with

TABLE 7. Moderation of stress on hypothesized paths (N=428).

DV	IV	coeff	se	t-value	p-value	LLCI	ULCI
Emotional well-being	constant	1.865	0.382	4.886	0.000***	1.115	2.615
	Stress	-0.118	0.049	-2.421	0.016*	-0.214	-0.022
	Convenience	0.034	0.047	0.727	0.467	-0.058	0.127
	Stress×Convenience	-0.096	0.047	-2.057	0.040*	-0.188	-0.004
	Administration	0.141	0.039	3.661	0.000***	0.065	0.217
	Infrastruture	0.088	0.054	1.629	0.104	-0.018	0.194
	Protection	-0.044	0.037	-1.192	0.234	-0.116	0.028
	Service	0.095	0.049	1.929	0.054+	-0.002	0.192
	Life satisfation	0.297	0.044	6.694	0.000***	0.210	0.384
	Gender	0.006	0.080	0.075	0.940	-0.152	0.164
	Age	-0.028	0.045	-0.627	0.531	-0.118	0.061
	Eduction	-0.046	0.069	-0.667	0.505	-0.182	0.090
	Income	0.051	0.057	0.899	0.369	-0.060	0.162
	Household	-0.139	0.093	-1.491	0.137	-0.323	0.044
	Social insurance	-0.011	0.108	-0.105	0.917	-0.224	0.202
	R	R-sq	F	df1	df2	p	
	0.512	0.262	10.483	14.000	413.000	0.000***	
DV	IV	coeff	se	t	p	LLCI	ULCI
Emotional well-being	constant	3.267	0.355	9.198	0.000***	2.569	3.965
	Stress	-0.119	0.050	-2.396	0.017*	-0.216	-0.021
	Life satisfation	0.303	0.044	6.823	0.000***	0.216	0.390
	Stress×Life satisfation	-0.062	0.038	-1.638	0.102	-0.135	0.012
	Administration	0.144	0.039	3.731	0.000***	0.068	0.220
	Infrastruture	0.087	0.055	1.590	0.113	-0.021	0.194
	Convenience	0.017	0.046	0.362	0.718	-0.074	0.108
	Protection	-0.045	0.037	-1.222	0.222	-0.117	0.027
	Service	0.100	0.049	2.021	0.044*	0.003	0.197
	Gender	0.001	0.080	0.007	0.995	-0.157	0.158
	Age	-0.026	0.046	-0.574	0.567	-0.116	0.063
	Eduction	-0.056	0.069	-0.807	0.420	-0.191	0.080
	Income	0.056	0.057	0.984	0.326	-0.056	0.167
	Household	-0.127	0.094	-1.349	0.178	-0.313	0.058
	Social insurance	-0.018	0.108	-0.162	0.871	-0.231	0.196
	R	R-sq	F	df1	df2	p	
	0.509	0.259	10.334	14.000	413.000	0.000***	

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

emotional well-being is not significant ($\beta = -0.031$ bias-corrected 95% CI $= -0.172$ to 0.105, including zero, $P > 0.05$). H3b was not supported.

E. TESTING OF HYPOTHESIZED INDIRECT EFFECTS

Instead of the Baron and Kenny's [64] causal steps test and Sobel test to examine mediation effects, we used bootstrap techniques to reach a robust mediation result [74] as shown in Table 6. First, this study verified the mediating role of stress in the relationship between perceived smart city development and emotional well-being. The results showed that perceived smart infrastructure significantly reduced emotional well-being through stress (indirect effect -0.031, CI $= -0.083$ to -0.006), and perceived smart public services significantly improved emotional well-being through stress (indirect effect 0.034, CI=0.008 to 0.080). H7c was

supported, and H7b was partially supported (the impact mechanism from negative to positive), which further demonstrates the direct effects result of H1c and H1b. Whereas perceived smart public administration (indirect effect −0.015, CI = −0.045 to 0.001) and perceived smart environmental protection (indirect effect 0.002, CI = −0.017 to 0.023) that affect emotional well-being through stress are not significant. H7a and H7d were not supported, which were similar to the test of H1a and H1d.

Second, the mediator role of convenience in the four relationships among perceived smart city development and emotional well-being are not significant (all indirect effect bias-corrected 95% CI are including zero, P < 0.05). H6 (H6a-H6d) was not supported, demonstrating the no significant direct effect between convenience and emotional well-being against.

Third, considering the multiple mediators for stress and life satisfaction, the test results showed that perceived smart public services significantly promoted life satisfaction by weakening stress, then improves emotional well-being (indirect effect 0.011, CI = 0.001 to 0.032). This was consistent with the empirical result of H1b and H7b, and H9b was partially supported (from negative impact mechanism to positive). But, perceived smart infrastructure significantly reduced life satisfaction by increasing stress, thereby weakening emotional well-being (indirect effect −0.010, CI = −0.031 to −0.001). H9c was supported. In addition, multiple mediators for stress and life satisfaction in perceived smart administration with emotional well-being, and perceived smart environmental protection with emotional well-being are not significant (both indirect effects bias-corrected 95% CI are including zero). Hence, H9a and H9d were not supported.

Fourth, as for the multiple mediators of convenience and life satisfaction, the results showed that perceived smart administration, perceived smart infrastructure, perceived smart public service, and perceived smart environmental protection can all promote emotional well-being by increasing convenience, and then improving life satisfaction (all indirect effects bias-corrected 95% CI are not including zero). Hence, H8 (H8a-H8d) were all supported.

F. MODERATING EFFECT OF STRESS

Following Aiken and West's [75] suggestion, the independent and moderator variables are mean-centered before the interaction is created. Therefore, the PROCESS program is set to center the mean values of stress, convenience and life satisfaction. That is, to convert the data of the three original variables to the mean value of zero. On the one hand, table 7 shows the coefficient for the interaction term of stress with convenience on emotional well-being is significant at 0.05 when controlling the influence of relative variables. And the bias-corrected 95% CI (−0.188, −0.004) does not include zero, supporting the above result against. Fig. 1 (simple slope test) depicted how the effect of convenience on emotional well-being varies depending on the strength of stress. As shown in figure 1, when the stress is high (stress at +1 SD), convenience has a negative relationship with emotional well-being; while the stress is low (stress at −1 SD), convenience has a positive impact on emotional well-being. H10a was supported. In addition, due to the positive and negative offsetting effects of convenience with emotional well-being, moderated by stress, the main effect between convenience and emotional well-being shown H3b is not significant (coefficient −0.031, CI = −0.172 to 0.105, including zero, P >0.05), meanwhile resulting in the no significance of mediation tests for H6 (H6a-H6b). On the other hand, the regression coefficient for the interaction terms of stress with life satisfaction on emotional well-being is not significant (coefficient −0.062, CI = −0.135 to 0.012, including zero, P > 0.05). It shows that the moderating effect of stress on the relationship between life satisfaction and emotional well-being does not exist. H10b was not supported.

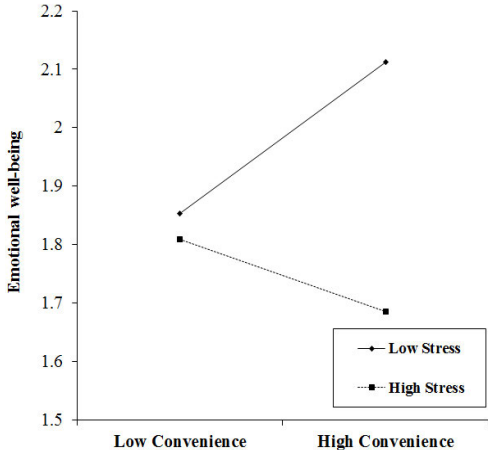


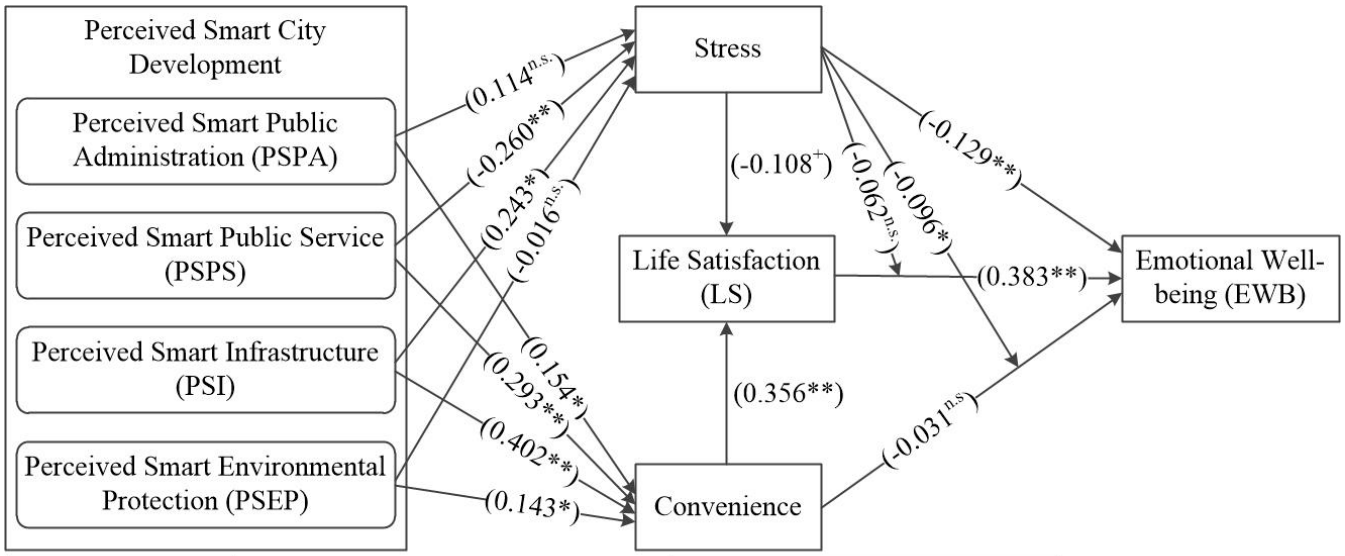
FIGURE 1. The moderating effects of stress.

V. CONCLUSION AND IMPLICATIONS

A. CONCLUSION AND DISCUSSION

The rapid development of smart cities has raised concerns about residents' emotional well-being (EWB). To enhance EWB when developing smart cities, policy-makers should take residents' perceptions and attitudes into account How can residents' perceptions about smart city development help promote their EWB? In this paper, we constructed a comprehensive model to explore the effect of perceived smart city development on residents' emotional well-being. Our study has yielded interesting results, summarized in Figure 2. The findings reveal that from the perspective of residents' perceptions, the development of smart cities has two effects on their emotional well-being. Further, four different dimensions of their perceptions concerning the development of smart cities follow different paths in influencing their emotional well-being.

First, PSI will reduce EWB by increasing stress; it can also decrease EWB via the mechanism of increasing stress and thereby reducing LS. This conclusion shows that although the



Mediation results	Multiple mediation results
PSPA-> Stress-> EWB (-0.015, not supported)	PSPA -> Stress -> Life -> EWB (-0.005, not supported)
PSPS-> Stress-> EWB (0.034, supported)	PSPS -> Stress -> Life -> EWB (0.011, supported)
PSI-> Stress-> EWB (-0.031, supported)	PSI -> Stress -> Life -> EWB (-0.010, supported)
PSEP-> Stress-> EWB (0.002, not supported)	PSEP -> Stress -> Life -> EWB (0.001, not supported)
PSPA->Convenience->EWB(-0.005, not supported)	PSPA->Convenience->Life->EWB(0.021, supported)
PSPS->Convenience->EWB(-0.009, not supported)	PSPS->Convenience ->Life->EWB(0.040, supported)
PSI->Convenience->EWB(-0.012, not supported)	PSI->Convenience-> Life-> EWB(0.055, supported)
PSEP->Convenience->EWB(-0.004, not supported)	PSEP->Convenience->Life-> EWB(0.019, supported)

+Significant at 0.1,* Significant at 0.05, ** Significant at 0.01, n.s. Not significant.

FIGURE 2. Empirical test results of the research.

application of smart city infrastructure can provide residents with a sense of convenience, it may also overrun urban green spaces and other residents' activity places, with the lack of urban green space for people's leisure activities being likely to increase the residents' sense of stress [76]. Another potential source of stress is the information recorded by smart infrastructure, as discussed previously. Further, smart infrastructure is likely to affect the residents' life negatively in the process of infrastructure construction due to the noise and road obstacles during the construction process. This conclusion is consistent with Lim's opinion regarding the negative impact ofr smart cities [77]. At the same time, PSPS can increase EWB by reducing stress; it can also increase EWB by through the mechanism of reducing stress and thereby improving LS. This conclusion shows that when residents perceive more smart city services, they can experience stronger feelings of convenience and also an enhanced ability to cope with difficulties, thereby reducing stress. This conclusion likewise indicates that the residents can enjoy smart city services rather than being concerned about potential privacy violations, and in that case smart services play a very important role in improving the emotional well-being of residents.

Second, PSPA, PSPS, PSI, and PSEP can enhance EWB via the mechanism of increasing convenience and thereby improving LS. This conclusion provides empirical evidence for the studies of Visvizi and Lytras [78] and Chamoso *et al.* [7], which highlight the positive effects of smart city development. These benefits for residents likewise explain why most current studies pay more attention to the construction of smart cities than to their potential problems.

Third, the statistically insignificant relationship between convenience and LS may be due to the interaction effect of stress and convenience, because the interaction term between convenience and stress has a significant effect on LS, resulting in the four insignificant indirect effects among PSPA, PSPS, PSI, PSEP and EWB via convenience. These conclusions indicate that there is a boundary condition for the positive effect between convenience and emotional well-being. Our findings also emphasize the important role of stress, which points to the potentially negative effects of smart city development.

B. THEORETICAL IMPLICATIONS

This paper makes several contributions to the domain of research on smart cities. First, previous research mainly focused on relevant technologies and their practical applications for smart city development, with few studies exploring residents' perceptions of smart city development [79], [27], especially when it comes to emotional well-being [9]. This article responds to Lytras *et al.*'s and Visvizi & Lytras's calls to investigate the social awareness of smart cities, and the impact of smart city development on residents' well-being [79], [80]. From the perspective of residents' perceptions, we explore the effect mechanism of perceived smart city development on emotional well-being, contributing to research on the sociopsychological impact of smart cities and smart city development.

Second, this study identified four main aspects of smart city development to measure residents perceived responses to such development. We also explored the different effect mechanisms among these four dimensions and emotional well-being, shedding further light on how smart city development affects residents' emotional well-being.

Third, existing research has mainly explored the positive impact of smart city development, neglecting its potentially negative effects [77]. Our study considers the convenience and stress that smart cities bring to residents at one and the same time, while also examining the interactions between these factors. The results show that the construction of smart cities needs to balance the trade-off between convenience and stress, with our study again drawing attention to the potential shortcomings or challenges associated with smart cities.

C. PRACTICAL IMPLICATIONS

Considering these findings, we recommend some managerial guidelines for smart city construction. First, the index of emotional well-being has important significance with respect to the construction of smart cities. Therefore, the residents' emotional well-being index, which can be formulated by constantly observing the residents' feelings about their lives in various cities, should be included in the appraisal system used to plan for smart cities' construction. Researchers should clarify the main factors influencing residents' emotional well-being, thereby providing the basis and direction for the construction of smart cities in future. Second, the most positive mechanism effect we discovered was the effect linking PSPI and EWB. This finding indicates that government departments can increase the provision of convenient services for residents, such as increasing the implementation of online government services, encouraging online transactions, and facilitating online taxi services, so as to improve further residents' life satisfaction and emotional well-being. Third, smart infrastructure, which has been emphasized as the most important aspect of the construction process of smart cities, influences residents' emotional well-being in two different ways. It can create new conveniences and thereby improve residents' emotional well-being; but it can also intensify residents' feelings of stress, which have a negative effect on life satisfaction and emotional well-being. Therefore, the advance of technology is a double-edged sword. When policy-makers are pushing for smart infrastructure, they should keep in mind that too much smart infrastructure may not lead to an increase in residents' emotional well-being. Instead, it may bring more stress into residents' lives. Policy-makers need to strike a balance between convenience and stress in developing smart infrastructure in order to minimize its negative impact on emotional well-being.

D. FUTURE RESEARCH DIRECTIONS

In the context of the rapid development of smart cities in China, the design and construction of new infrastructure are well underway. For example, the Chinese government has been accelerating investment in new infrastructure projects in 2020, including 5g base stations, intercity high-speed railways, urban rail transit, new energy vehicle charging piles, big data centers, artificial intelligence, and so forth. Against this backdrop, whether the construction of China's smart cities will have an ameliorative effect on residents' life, or whether the general public will think the intelligence of smart cities is "too much" or "overwhelming," is an interesting and important research area to explore. Second, considering the differences in digital skills between younger and older urban residents, the question of whether the digital divide will create divergent attitudes toward smart cities also needs to be further investigated. Third, the data used for this study are derived from the Chinese context and the model results may be different elsewhere due to the influence of different national cultures. Hence, future research should consider the impact of different national contexts on the findings outlined here.

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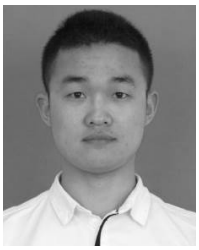

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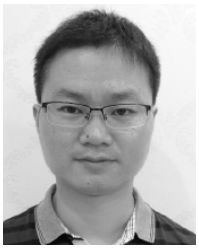

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