Research article

The Impact of Employees' Perception of Smart Cities on Employee Green Behavior: A Moderated Mediation Model

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Abstract: The issuance of the 2022 White Paper on Smart Cities has brought the notion of smart cities to the forefront. This conceptual framework revolves around green and sustainable development, aligning seamlessly with China's mission to strengthen ecological civilization in the contemporary era. In this study, we delve into the implications of employees' perception of smart cities on their ecologically conscious behaviors, drawing upon the frameworks of self-determination theory. The empirical analysis encompasses 306 employee respondents hailing from diverse enterprises and backgrounds. The findings extracted from this investigation reveal several crucial insights: (1) A robust and positive correlation between the employees' perception of smart cities and their eco-friendly behaviors; (2) corporate environmental responsibility assumes a partially mediating role between the employees' perception of smart cities and eco-friendly behaviors; (3) environmental awareness emerges as a constructive moderator in the interplay between corporate environmental responsibility and employees' eco-friendly behaviors; (4) notably, the impact of employees' perception of smart cities on employees' eco-friendly behaviors assumes greater prominence when environmental awareness is high, signifying an intensified indirect relationship. This dynamic underscores that during periods of heightened environmental awareness, the influence of employees' perception of smart cities on eco-friendly behaviors becomes more pronounced, reinforced by a more substantial indirect influence

channeled through corporate environmental responsibility. These findings enhance the theoretical underpinnings of self-determination theory. Enterprises are encouraged to underscore and incentivize employees' pro-environmental behaviors, integrate environmental preservation paradigms into corporate culture and enhance green management initiatives, synergistically advancing shared ecological objectives for both enterprises and employees.

Keywords: smart city; Green low-carbon; self-determination theory

1. Introduction

With the rapid acceleration of urbanization and the swift advancement of information technology, China's economic and society have witnessed a fundamental development. However, this rapid developing process has also brought about some problems, such as over-exploitation of natural resources and environmental pollution [1,2]. Due to the expansion of urban area, a considerable amount of carbon has been emitted into the atmosphere over recent decades [3]. Furthermore, the wastewater from daily activities of urban residents also causes a noticeable pollution issue [4]. Many studies have been conducted trying to settle these problems. It is believed that the smart cities may have the potential to improve the current situation [5,6].

"Smart cities" is a concept of urban development. By fully utilizing information technology, smart cities can help to achieve the intelligent management of modern cities and to provide residents with a more efficient and convenient daily environment [7]. Moreover, the influence of this smart cities concept transcends beyond the mere comprehensive alterations in urban infrastructure and public services. As a concept that can handle environmental and social challenge [8], it also encompasses the realms of sustainable development, environmental preservation and social responsibility [9]. Since there is a large overlapping area exists between smart city concept and green-sustainable development [10], many studies have been conducted to research on the green-sustainable development and the smart cities development. It is found out that the adoption of green sustainable development has emerged as an optimal path for the advancement of the smart city [11], the crux of which entails an active endorsement of environmental conservation, energy efficiency and low-carbon models in urban planning and operations [12], aimed at curtailing resource wastage and environmental degradation [13].

Under the direction of smart cities concept, green-sustainable development will take a huge step forward. The smart cities concept necessitates not only collaborative efforts between governmental bodies and enterprises but also active engagement from employees and their practical embodiment of eco-friendly practices. Enterprises wield a pivotal role in this trajectory, as they are tasked not only with integrating ecological principles into their functioning and administration but also with cultivating environmentally responsible conduct among their employees to ensure the seamless integration of green paradigms across all dimensions of the enterprise [14]. As integral constituents of the urban landscape and the largest producer of carbon emissions [15], enterprises not only partake in constructing the green-sustainable development of the city but also stand as crucial agents in realizing ecologically mindful, low-carbon and socially responsible urban environments. Employees, in turn, assume the mantle of the vital impetus for enterprises' sustainable evolution and eco-centric

transformation. The green behavior exhibited by employees directly influences enterprises' environmental performance and in turn promotes the further development of smart cities [16].

Inspired by a case study pointing out that the citizens' perception of smart city concept has the potential to influence their engagement and behaviors [8], we want to further explore the mechanisms how the employees' perception of smart city concept shapes their green behaviors. The significance of the smart city concept in fostering sustainable urban development is widely acknowledged; however, more comprehensive research is needed to clarify the impact of employees' perception of smart cities on their green behaviors [16]. Although studies have addressed the impact of the smart city concept on enterprises [17], a relative scarcity persists in investigating the nuanced guidance and facilitation of employees' eco-conscious behaviors within the context of this paradigm. As enterprises and employees take on increasingly pivotal roles in steering green development within smart city contexts, this study endeavors to address this knowledge gap by thoroughly exploring the mechanisms by which the employees' perception of smart city can shape their environmentally responsible actions.

The self-determination theory (SDT) studies the motivation of human beings. It was first developed by Ryan and Deci [18] and improved by several scholars; it underscores the role of autonomous and controlled motivation in shaping people's behavior [18,19]. Based on this, we can infer that employees' perception of smart cities concept may generate green behavior by stimulating employees' autonomous and/or controlled motivation. Furthermore, the application of SDT in this study also aids in comprehending the moderating role of environmental awareness in mediating the relationship between the employees' perception of smart city and their green behavior.

Previous studies on SDT have found that there are two types of human motivation (autonomous motivation and controlled motivation) and posited that individual behaviors are usually motivated by joint effort of both intrinsic and extrinsic forces [18,20]. Extrinsic-motivated behaviors occur when people try to satisfy external demand, expect a reward or avoid punishment, while intrinsic-motivated behaviors occur when people can get inner happiness, self-satisfaction and meeting their own interest. With a higher degree of perception and a deeper understanding of smart city concept, employees might find themselves intrinsically motivated to partake in environmentally conscious actions due to their alignment with the city's vision of green and sustainable development [21]. Driven by this sense of identification, they will feel proud and happy after conducting the green behavior. For instance, they might willingly adopt eco-friendly practices, such as conserving energy and reducing waste, driven by an internal resonance with the principles of environmental protection with expectations for self-satisfaction. Furthermore, due to the increasing engagement of government management and regulation restrictions in the concept of smart cities [22], employees need to implement green behaviors according to government and legal requirements, by which means they can maintain the legitimacy of their actions and avoid being punished. Thus, self-determination theory (SDT) furnishes theoretical underpinning to elucidate the constructive impact of employees' perception of smart cities on their green behavior.

In the present study, environmental awareness assumes the role of a moderating variable [23,24], signifying the extent of employees' awareness and the significance they attribute to green development. With a higher environmental awareness, employees will have a better understanding of external regulations related to environmental protection therefore avoid conducting anti-green behaviors. They will also gain a sense of satisfaction and mission in the process of conducting green behavior. The joint efforts of extrinsic and intrinsic motivation that environment awareness brings about may make employees more willing to integrate their green and sustainable perceptions from the concept of smart

cities into their daily behaviors. At this juncture, environmental awareness emerges as a moderating factor, amplifying the affirmative impact of the employees' perception of smart cities on their green behavior. Conversely, if employees possess limited environmental awareness, their motivation to partake in green behaviors may be diminished, thereby potentially curbing the influence of their perception of smart cities. In this way, the self-determination theory (SDT) also furnishes a theoretical foundation for expounding the pivotal moderating role of environmental awareness within the nexus of employees' perception of smart cities on their green behavior.

Guided by the tenets of the self-determination theory, we aim to comprehensively fathom the impact of employees' perception of smart city on their environmentally-conscious behaviors. Inspired by the research structure proposed by Huang and Guo (2023) [25], we selected corporate environmental responsibility as a mediating variable and environmental awareness as a moderating variable, culminating in constructing an intricate research model (Figure 1). Incorporating corporate environmental responsibility as a mediating variable within the research model provides a framework through which the manifestation of the perception of smart city within corporate environmental responsibility can be elucidated. This, in turn, shapes employees' green behaviors. Using environmental awareness as a moderating variable enables us to discern any distinctions in the magnitude of influence exerted by the perception of smart city on employees' environmentally conscious behaviors across varying degrees of environmental awareness.

By delving deeply into the influence mechanism of employees' perception of smart cities on their green behavior, this study accomplishes two significant outcomes. It enhances the theoretical underpinning of the self-determination theory. It offers a pivotal guide for enterprises that foster green development and fortify their green management strategies in practical contexts. By integrating environmental principles into the fabric of corporate culture, stimulating employees' environmental awareness, and cultivating an organizational milieu conducive to eco-friendly practices, companies can effectively help to achieve the urban's intelligent development. As a result, they can effectively pave the way for a more sustainable and livable developmental landscape, benefiting their workforce and society.
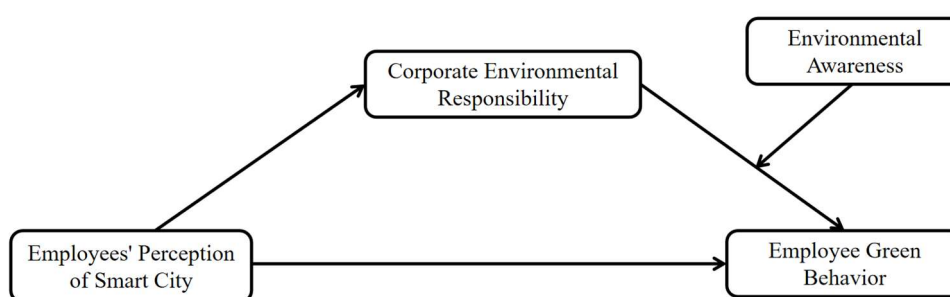

Figure 1. Logic diagram of the study.

2. Theory and research hypothesis

In forthcoming sections, we will expound upon 1. the direct impact of employees' perception towards smart cities on their green behavior, 2. The intermediary role played by corporate environmental responsibility and 3. the moderating influence of environmental awareness. Through a

comprehensive exploration of these dynamics, we aspire to foster a more profound comprehension of the influence mechanisms of the perception about smart city concept within organizational frameworks in tandem with the behavioral responses of individuals in this context.

2.1. Influence of Employees' Perception about Smart City on Their Green Behavior

The definition of smart city is currently undergoing rapid development and we are unclear about the finalized version of smart city concept. However, current literature on the smart cities is mostly focused on the application of digital innovation to the development of urban area, allowing the cities to be smarter, more efficient, more sustainable and more livable [26–30]. In general, the smart city concept revolves around utilizing information technology to realize intelligent and sustainable urban management and development [31]. When people have a higher level of perception or understanding of smart city, they will have a higher awareness towards the significance of the green and sustainable development of urban area, thus implementing more green behavior.

Current studies on the employees' green behavior (EGB) classify the behavior into two groups: required EGB and voluntary EGB [32]. As companies pursue the improvement of their environmental performance by introducing green jobs and duties [33], required EGB occurs while employees are demanded by their employers and this required EGB is closely related to companies' core business. The other type of EGB is voluntary EGB, a green behavior involving personal initiative that exceeds organizational expectations. This includes prioritizing environmental interests, initiating environmental programs and policies and encouraging others [32].

The self-determination theory finds that individual behaviors are driven by two types of human motivation: autonomous motivation and controlled motivation [18,20]. Controlled motivation will result in required EGB [32], as employees get the instruction from their employers to conduct EGB to better achieve the environmental performance. This type of green behavior is propelled by a desire to satisfy external demand, by an expectation towards a reward or by the nature to avoid punishment. If an employee can have a good perception of the smart city, they will have a clearer understanding of what aspects should be taken to achieve the green behavior required by the smart city for the enterprise (i.e., have a clear knowledge about what the company need them to accomplish), in which case they might help the enterprise better assume green responsibility. Moreover, autonomous motivation will foster a voluntary EGB [32], indicating that the employees will choose to actively reach far beyond what is required by employer concerning the environmental behavior. This self-driven green behavior is developed by the need to get inner happiness, to find self-satisfaction and to meet their own interest. When employees have a high perception of smart cities, they will automatically develop a sense of identity and mission towards the green and sustainable development of the city, which drives them to actively engage in green behavior and reaps a sense of moral satisfaction from shouldering the environment and social responsibility [34]. Also, when we discuss employees' green behavior in a general way, we do not deliberately distinguish their initial nature. This is because the EGB is sometime driven by a joint effort of intrinsic and extrinsic forces [18,20], and we cannot simply define it into a specific type. Employees may have initially conducted green behavior as required due to the instructions from the employer. However, employees themselves gradually discover that they can obtain a sense of satisfaction and achievement through the process of exercising green behavior, which will in turn leading to more spontaneous green behavior.

In summary, employees' perception of smart city can instigate affirmative changes in employees' green behaviors by eliciting intrinsic and/or extrinsic needs, and also furnishing avenues for green practices. Thus, we propose:

Hypothesis 1: A positive correlation exists between employees' perception of smart city and employees' environmentally conscious behaviors.

2.2. The mediating role of corporate environmental responsibilities

As mentioned earlier, companies pursue the improvement of their environmental performance by introducing green jobs and duties [33]. This is a manifestation of corporate environmental responsibility and has assumed great significance within the context of smart city, acting as a pivotal factor. Advocates who have a deeper understanding of the smart city underscore the significance of green sustainability and environmental protection, factors that could incite heightened awareness and corporate actions towards responsibility [35]. Given people's constantly escalating environmental awareness, we further explore the mediating role of corporate environmental responsibility between the perception of smart city and employees' green behaviors. This mediation could be nuanced in practical scenarios yet remains vital in fostering environmentally conscious conduct.

Corporate social responsibility (CSR) is a concept by which companies voluntarily contribute to a better society and a cleaner environment [36], and the ecological dimension of CSR is corporate environmental responsibility (CER). The main driven force of corporate environmental responsibility (CER) is pressure from stakeholders [37], and the stakeholder is defined as 'any group or individual who can affect, or is affected by, the achievement of a corporation's purpose' [38]. Employees, as internal stakeholders, have an impact on corporate environmental responsibility. Previous studies have proved that the company's stakeholders will urge the company to focus not only on short-term economic achievement [38] but also on the implementation of corporate environmental strategies to fulfill its corporate environmental responsibility [39]. With the help of internal stakeholders (employees), the company's corporate environmental responsibility is influenced positively and directly [40]. When employees have a good perception of smart cities, they can deeply understand the green and sustainable development goals embedded in the concept, thus resonating with the environmental responsibility of enterprises. This sense of resonance and identification generated by the comprehensive perception of smart city concept can drive these internal stakeholders (employees) to be more proactive in providing their help, thereby promoting the improvement and achievement of corporate environmental responsibility. Therefore, we propose Hypothesis 2:

Hypothesis 2: A positive correlation exists between employees' perception of smart city and corporate environmental responsibility.

The green responsibilities assumed by organizations are gaining increasing significance and implementation within the framework of the smart city concept. This heightened attention and focus on green responsibility carry the potential to exert an influence on the eco-friendly behaviors of employees [41]. Drawing upon insights from self-determination theory, we can better understand the mechanisms underpinning this influence and shed light on the mediating role of corporate environmental responsibility [41]. Within this context, we will delve into how corporate environmental responsibility can connect employees' perception of smart city and their environmentally conscious behaviors, thereby infusing greater purpose and efficacy into environmental initiatives across companies.

The green sustainability goals emphasized by the Smart City concept resonate profoundly within the corporate landscape [42]. Positioned as a leading strategic imperative, these sustainability goals extend beyond mere responses to environmental challenges; they embody the core values of corporations. The widespread dissemination of this philosophy necessitates companies to take a more proactive stance towards environmental responsibility within their business operations. Within this framework, a corporate ethos that emphasizes green responsibility serves not only as a mode of external image projection but also as an embodiment of an internal mission [43]. This alignment between internal and external spheres will not only heightens employees' environmental awareness within the company [44], but also function as a booster by introducing regulation, reward and punishment to employees, propelling them towards a more positive engagement in eco-friendly practices.

According to self-determination theory, intrinsic and extrinsic forces are crucial in the formation of behavior [18,20]. When the company's environmental responsibility is perceived by their employees, they are more likely to develop an identification with their organization, and this perceived CER will then indirectly impact employees' green behavior through their organizational identification [45]. While the company values environmental responsibility, it will gradually convey a value of environmental protection to its employees. When employees resonate with this value, they can gain a sense of satisfaction in actively engaging in green behavior. This intrinsic happiness and fulfillment will then continue to encourage the employees to conduct green behavior. Furthermore, in order to better assume the corporate environmental responsibility, enterprises will propose behavioral norms with rewarding and punishment measures to employees. These rewarding and punishment set by the company are the extrinsic motivations towards the employees and they will commonly tend to exercise green behavior to receive rewards and avoid punishment. The internal and external driving forces generated by corporate environmental responsibility transmit a positive signal within the company, directly and positively affecting employees' attitudes towards environmental protection and their green behaviors. Guided by this constructive environment, employees are more likely to view corporate green responsibility as a pivotal guiding element, thus proactively integrating green behaviors into their work practices [46]. Based on this, we propose the following hypothesis:

Hypothesis 3: A positive relationship exists between corporate environmental responsibility and employee eco-friendly behavior.

According to self-determine theory, employees' perception of smart city can have a positive impact on corporate environmental responsibility. Moreover, by elevating corporate environmental responsibility, enterprises can effectively utilize external and internal motivation to enhance employees' proactive participation in adopting eco-friendly behaviors. The intricate interplay among the influence of the employees' perception of smart city, the underpinning of self-determine theory and the presence of organizational green responsibility synergistically jointly shape the employees' environmental mindfulness and their behavioral motivation. Considering these synergies, we posit:

Hypothesis 4: Corporate environmental responsibility mediates the relationship between the employees' perception of smart city and employee eco-friendly behaviors.

2.3. The moderating role of environmental awareness

The impacts of employees' perception of the smart city on their behavior and corporate environmental responsibility may vary due to the complexity and continuous changes of influencing

factors. However, the level of environmental awareness may function a major factor determining the degree of relative impact.

Environmental awareness, as a manifestation of an individual's internal stance, wields a potential moderating influence within the realm of green responsibility [47]. In the context driven by the smart city concept, the impetus towards corporate green responsibility might shape employees' environmental awareness, potentially influencing their engagement in green behaviors [46]. According to the self-determination theory, internal motivation is part of the driven force of people's behavior [18,20]. Therefore, environmental awareness is pivotal in determining how employees respond to the organization's green responsibility. When employees manifest elevated vigilance and concern for environmental issues, they are more inclined to comprehend and align with the organization's green responsibility, in which case they will develop an intrinsic motivation and a sense of obligation to contribute to society and the welfare of future generations [48], thus fostering more proactive engagement in green behaviors [49]. In this capacity, environmental awareness operates as a "moderator", capable of fine-tuning the correlation between individual environmental inclinations and organizational green responsibility, thereby impacting the manifestation of green behaviors. Therefore, we propose the following hypotheses:

Hypothesis 5 (H5): Environmental awareness positively moderates corporate environmental responsibility and employee green behavior.

Moreover, environmental awareness, functioning as an intrinsic psychological state within an enterprise and its employees, wields significant influence over an individual's comprehension of and response to the enterprise's environmental responsibility [44]. Under the aegis of the smart city concept, the enterprise's ecological commitment traverses the sphere of employees' environmental awareness, thus wielding a cascading influence over their green behaviors. In this milieu, environmental awareness is a "mediating factor", operating as a moderator within the overarching influence mechanism, thereby modulating the correlation between corporate environmental responsibility and employees' green behaviors.

The perspective furnished by the self-determination theory affords us a more holistic understanding of the role of environmental awareness. Environmental awareness, influenced by a combination of age, education level and social status [50], transcends being a mere internal attitude of an individual. It is a psychological state capable of seamlessly integrating the individual with the external environment [51]. Guided by the employees' perception of smart city, the enterprise's environmental commitment imparts a resonance to employees' green behavior by igniting their internal environmental awareness [46]. Within this mechanism, environmental awareness is pivotal, acting as a conduit of information transfer that establishes and regulates the nexus between corporate environmental responsibility and employees' conduct [52]. By elevating employees' cognizance of corporate green responsibility, the organization is apt to catalyze an augmented level of environmental consciousness among the workforces. This heightened awareness, in turn, catalyzes more robust employee engagement in green behaviors [53]. Concurrently, this heightened environmental consciousness can also bolster employees' alignment with the organization's green responsibility, thereby propelling more active integration into the praxis of green behaviors. Hence, we posit:

Hypothesis 6 (H6): Environmental awareness positively moderates the mediating role of corporate environmental responsibility between employees' perception of smart city and employee green behavior.

To recapitulate, environmental awareness, which manifests an individual's intrinsic disposition, stands poised to fulfil a favorable moderating role between corporate environmental responsibility and employees' green behaviors. The propulsive force of the employees' perception of smart city accentuates this dynamic. Within this context, the influence of environmental awareness, through the prism of the self-determine theory, enhances clarity. This heightened insight enables refining our comprehensive model to elucidate the interplay between employees' perception of smart city and employee conduct.

3. Research methods

3.1. Sample and Procedure

To scrutinize our hypotheses, we employed a survey-based approach, utilizing a questionnaire tailored to assess the impact of employees' perception of smart city on their green behaviors. Our outreach encompassed a diverse array of enterprises, focusing on those categorized as energy-consuming, manufacturing, high-tech, Internet-based and new energy ventures. By casting a broad net, we aimed to garner nuanced insights into the nexus between the smart city concept, employees' eco-friendly conduct and the underlying catalysts.

The collection of data was conducted via an online questionnaire platform. Participants who are invited and agree to take part in the survey will receive a webpage link through which they can open and complete the questionnaire. Furthermore, participants are suggested to choose a quiet and undisturbed environment to ensure a thoughtful answer. In addition, we implement strict confidentiality measures for participants and their questionnaires as all questionnaires are anonymous and their answers are well protected. A total of 306 questionnaires were amassed, out of which 305 met the criteria for validity. Gender distribution within the participant pool exhibited a semblance of equilibrium, with 154 male and 152 female respondents, the former representing approximately 50.5% and the latter 49.5% of the aggregate sample. Regarding age composition, a dominant majority of 201 respondents fell within the age bracket of 26 to 35 years, constituting around 65.9% of the total sample. Notably, the highest respondent count was recorded within the narrower age range of 26 to 30 years, accounting for 101 participants or approximately 33.1% of the entire sample.

Educational qualifications of the participants were diverse, with 144 individuals holding undergraduate degrees, representing about 47.2% of the total cohort. Following this, those with higher vocational and advanced degrees totaled 116, contributing to roughly 38.2% of the participant pool. Spanning multiple industry types, the survey drew participation from various sectors: High-energy-consuming enterprises yielded 43 responses (14.1%), manufacturing firms accounted for 71 responses (23.3%), high-tech enterprises contributed 66 responses (21.6%), Internet-based companies furnished 76 responses (24.9%) and new energy enterprises submitted 50 responses (16.4%).

Furthermore, considering work experience, the highest number of respondents, constituting 102 participants (33.4%), reported having over a decade of work experience. Subsequently, those with a work span of 1 to 3 years accounted for 78 participants (25.6%).

3.2. Measures

We collected data through a questionnaire, capturing participants' perspectives across various dimensions: Their perception of smart city, corporate environmental responsibility, employees' green behaviors and environmental awareness. All variables were assessed on a 5-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree). To ensure the reliability and validity of the questionnaire, we curated questions from established scales. The sample was derived using a random sampling technique to encompass diverse views and attitudes from employees spanning different enterprise types.

Regarding the employees' perception of smart city, we primarily drew inspiration from the questionnaire and scale developed by Kamil Roman [54]. Building upon this foundation, we crafted a series of inquiries that comprehensively explored respondents' perception of smart city. The scale consists of questions such as 'Do you agree that you have a good overall perception towards the level of new smart city construction in this city', 'Do you agree that you have a good perception of the coverage and construction level of intelligent public infrastructure' [55] and 'Do you agree that you have a good perception of the service completion rate and experience level of the smart livelihood service platform' [56]. The Cronbach's α coefficient for this scale in our study measured a robust 0.904.

For corporate environmental responsibility, we referenced the works of Tian Jiahui and other scholars [57–59] as a cornerstone. Elaborating on their framework, we formulated questions about participants' evaluations of their company's corporate environmental responsibility in the aspects of corporation's environmental protection strategy, green production technology, sustainable development goals and corporation's involvement in environmental preservation endeavors. The scale comprises items such as 'Do you agree that your company has considered environmental protection when formulating its business strategy' [57], 'Do you agree that your company has participated in activities aimed at protecting and improving some natural environments' [58] and 'Do you agree that your company invests a lot of resources in developing green production technologies' [59]. We recorded a Cronbach's α coefficient of 0.906 for this scale.

Concerning employees' green behaviors, our foundation was the questionnaire and scale devised by Zhang Baojie and colleagues [21,58–60]. We extended their inquiry by addressing actions like the execution of environmental responsibilities at work and promoting ecological conduct among colleagues. The scale is made up of items such as 'Do you agree that you have seized the opportunity to actively participate in environmental protection in your work' [21], 'Do you agree that you will propose suggestions to improve organizational environmental performance in the company' [58], 'Do you agree that you have fulfilled your job responsibilities in an environmentally friendly manner' [59] and 'Do you agree that you will encourage colleagues to adopt more environmentally conscious behaviors' [60]. The Cronbach's α coefficient for this scale in our study was 0.910.

Concerning environmental awareness, we harnessed the questionnaire and scale advanced by Zhang Baojie and associates [60]. Our adapted questions explored the depth of respondents' appreciation for environmental preservation, their engagement with environmental knowledge and their actual eco-friendly practices. The scale consists of items such as 'Do you agree that establishing environmental awareness is important', 'Do you agree that you are interested in environmental protection knowledge' and 'Do you agree that you will actively learn energy-saving and environmental protection knowledge to improve environmental protection capability' [60]. The Cronbach's α coefficient for this scale in our study reached 0.907.

The preceding overview encapsulates our sample selection strategy and the measurement tools employed. The culmination of our data collection and subsequent analysis aims to illuminate the interplay between the employees' perception of smart city, employees' green behaviors and the nexus of organizational green responsibility and environmental awareness. Elaborate data analyses and findings will be expounded upon in subsequent chapters.

4. Data analysis and results

4.1. Common method bias test

To safeguard against potential methodological biases, Harman's one-way test was initially employed to scrutinize the study variables. The findings disclosed that the unrotated first factor accounted for 31.645% of the variance—a percentage below the established 40% threshold. Consequently, it can be inferred that the study remains free from the concern of common method bias.

4.2. Reliability test and validity test

Table 1 presents the outcomes of the reliability assessment conducted through AMOS 24.0. The internal consistency (Cronbach's α coefficient) and composite reliability (CR) of the four variables— namely, smart city concept, corporate environmental responsibility, environmental awareness and employees' green behavior—exceeded 0.70. The Average Variance Extracted (AVE) values also surpassed 0.5, indicating robust internal consistency and reliability across all variables.

Table 1. Results of reliability and validity analysis.

Variables	Standardised factor loadings	Cronbach'α	CR	AVE
1.Employees' Perception of Smart City	0.760–0.790	0.904	0.9039	0.6108
2.Corporate Environmental Responsibility	0.760–0.800	0.906	0.9063	0.6174
3.Environmental Awareness	0.752–0.805	0.907	0.9065	0.6178
4.Employee Green Behavior	0.749–0.825	0.910	0.9094	0.6263

Table 2. The results of confirmatory factor analyses.

Variables	KMO	Bartlett's	Sig
1.Employees' Perception of Smart City	0.917	1007.259	0.000
2.Corporate Environmental Responsibility	0.915	1035.122	0.000
3.Environmental Awareness	0.916	1036.438	0.000
4.Employee Green Behavior	0.912	1080.325	0.000
Total	0.936	4506.351	0.000

The validation procedure was executed using SPSS 25.0, and the outcomes underscore the robustness of our approach. Specifically, the Kaiser-Meyer-Olkin (KMO) values for each variable and the cumulative dimensions within the questionnaire all exceeded the threshold of 0.70. This outcome signifies the suitability of the questionnaire data for factor analysis. Bartlett's test of sphericity further substantiates the validity of the dataset. The resulting significance probability (P) of 0.000 (P < 0.01)

unequivocally rejects the null hypothesis of Bartlett's test, suggesting the presence of a coherent underlying structure within the data—a prerequisite for factor analysis. A visual representation of these results is presented in Table 2.

4.3. Descriptive statistics and correlation analysis

We employed SPSS 25.0 for descriptive statistics and correlation analyses of the collected data to comprehensively examine the relationships within our framework. The outcomes are meticulously documented in Table 3, revealing no outliers in the means and standard deviations across variables.

The results underscore the intricate connections among critical constructs. The employees' perception of smart city correlates significantly with employee green behavior (B = 0.396, P < 0.01). Similarly, a noteworthy correlation is observed between the perception of smart city and corporate environmental responsibility (B = 0.414, P < 0.01). It is important to note that corporate environmental responsibility significantly correlates with employee green behavior (B = 0.409, P < 0.01). A significant association is also unveiled between corporate environmental responsibility and environmental protection awareness (B = 0.450, P < 0.01). Moreover, the relationship between environmental protection awareness and employee green behavior (B = 0.439, P < 0.01) is substantial. These outcomes collectively offer robust preliminary support for our hypotheses.

Table 3. Means, standard deviations, correlations.

Variables	Mean	SD	1	2	3	4	5	6	7
1. Gender	1.500	0.501							
2. Age	2.790	1.171	−0.092						
3. Education	3.640	0.775	−0.051	−0.219**					
4. Tenure	3.410	1.384	−0.092	0.860**	−0.132*				
5. EPS	3.314	0.963	−0.090	0.012	0.037	0.055			
6. EGB	3.409	0.975	−0.054	0.063	0.042	0.056	0.396**		
7. CER	3.332	0.956	−0.064	−0.007	0.005	−0.017	0.414**	0.409**	
8. EA	3.351	0.964	−0.034	0.002	0.027	−0.006	0.370**	0.439**	0.450**

Notes. N = 306. SD: Standard Deviations; *: p < 0.05; **: p < 0.01; ***: p < 0.001.

Employees' Perception of Smart City = EPS; Corporate Environmental Responsibility = CER; Environmental Awareness = EA;

Employee Green Behavior = EGB.

4.4. Hypothesis testing

The hypotheses proposed in this study underwent rigorous examination via hierarchical linear regression analysis employing SPSS 25.0. The comprehensive outcomes of this analysis are briefly presented in Table 4.

The data underwent standardization before hypothesis validation to ensure robustness in our testing. Moreover, a careful assessment of the Variance Inflation Factor (VIF) for each model was conducted during testing, with all VIF values below 3. This meticulous evaluation assures us that the concern of multicollinearity is effectively mitigated.

4.4.1. Main effects test

We commenced our analysis by testing the association posited in hypothesis 1 concerning the employees' perception of smart city and its connection to employees' green behaviors. The outcome of this assessment is meticulously presented in Table 4. Model 1 of the table conveys the significant and affirmative correlation between the smart city concept and employees' green behaviors (B = 0.400, P < 0.001), affirming the validity of hypothesis 1.

4.4.2. Tests for mediating effects

To scrutinize the mediating influence of corporate environmental responsibility between the employees' perception of smart city and employees' green behaviors (H4), we employed the stepwise regression technique as proposed by Wen Zhonglin and Ye Baojuan [61]. The results of this analysis are meticulously delineated in Table 4. The procedural breakdown is as follows: 1. Test the relationship between the perception of smart city and corporate environmental responsibility (H2): the perception of smart city positively affects corporate environmental responsibility (B = 0.414, P < 0.001, Model 2), Hypothesis 2 is established; 2. Test the relationship between corporate environmental responsibility and employee green behavior (H3): corporate environmental responsibility positively affects employee green behavior (B = 0.417, P < 0.001, Model 3); 3. It can be seen from Model 4 that after adding the corporate environmental responsibility, the positive correlation effect of the employees' perception of smart city on employees' green behaviors is weakened (Model 4, b = 0.274, p < 0.001), and the degree of model fit is improved (R2 = 0.237). From the above data, it can be tentatively shown that corporate environmental responsibility mediates between the perception of smart city and employee green behavior.

Table 4. Regression results for direct effect model and mediation model.

Variables	Model1	Model2	Model3	Model4
	EPS →EGB	EPS→CER	CER→EGB	EPS→CER EGB
Constant	1.858***	2.049***	1.632***	1.233**
Gender	−0.026	−0.049	−0.034	−0.011
Age	0.115	0.009	0.056	0.098
Education	0.056	0.033	0.070	0.058
Tenure	−0.056	−0.069	0.008	−0.035
Perception of Smart City	0.400***	0.414***		0.274***
Corporate Environmental Responsibility			0.417***	0.305***
R2	0.164***	0.178***	0.175***	0.237***
F	9.745***	10.758***	12.722***	13.206***

Notes. N = 306; *: p < 0.05; **: p < 0.01; ***: p < 0.001.

Employees' Perception of Smart City = EPS; Corporate Environmental Responsibility = CER; Environmental Awareness = EA; Employee Green Behavior = EGB.

4.4.3. Tests for mediating effects

To validate the mediating role of corporate environmental responsibility, this study employed the Process_v4.5 tool within the SPSS software for a comprehensive Bootstrap test. The results are meticulously presented in Table 5. The derived data unmistakably reveals that the mediating effect, through which the employees' perception of smart city influences employees' green behavior by way of corporate environmental responsibility, stands at 0.1252. This substantial figure constitutes 31.3% of the total effect, and its confidence interval [0.0753, 0.1805] conspicuously excludes 0. In light of this, Hypothesis 4 can be unequivocally affirmed.

Table 5. Bootstrap test of mediating effect.

Path	Effect Value	SE	BootLLCI	BootULCI	Effectiveness ratio
Total effect	0.4002	0.0540	0.2940	0.5064	
Direct effects	0.2750	0.0568	0.1633	0.3868	68.7%
Indirect effects	0.1252	0.0269	0.0753	0.1805	31.3%

Notes. N = 306. Unstandardized regression coefficients are reported. Bootstrap sample size 5,000. LL = lower limit; UL = upper limit; CI = confidence interval.

4.4.4. Moderating effects test

In this study, we employed an approach to mitigate multicollinearity among variables by decentering them. The collected data were analyzed using SPSS 25.0, and the analysis outcomes are presented in Table 6. As delineated in Table 6, the interaction between corporate environmental responsibility and environmental awareness protection exhibits a noteworthy and positive impact on employees' environmentally conscious behaviors (B = 0.153, p < 0.001). This finding indicates that environmental protection awareness plays a constructive moderating role in shaping the relationship between corporate environmental responsibility and employees' environmentally conscious behaviors. Specifically, a heightened level of environmental protection awareness accentuates the favorable connection between corporate environmental responsibility and employees' eco-friendly behaviors, thereby providing initial support for Hypothesis 5. The outcome illustrates that a greater degree of environmental awareness amplifies the favorable correlation between corporate environmental responsibility and employees' green behavior, thus corroborating the preliminary validation of Hypothesis 5.

To facilitate a more coherent exploration of the moderating influence of environmental awareness on the relationship between corporate environmental responsibility and employees' environmentally conscious behaviors, the sample was bifurcated into two distinct cohorts based on their levels of environmental awareness: those exhibiting high and low environmental awareness. Subsequently, the moderating effect was examined within the contexts of these two categories, characterized explicitly by one standard deviation below the mean (Mean − 1SD) and one standard deviation above the mean (Mean + 1SD) levels of environmental awareness. The outcomes of this examination are visually presented in Figure 2.

Table 6. Regression results for conditional indirect.

Predictor	EGB			
	B	SE		
Moderation model				
Constant	1.122**	0.392		
Gender	−0.025	0.097		
Age	0.072	0.083		
Education	0.073	0.064		
Tenure	−0.013	0.069		
CER	0.243***	0.057		
EA	0.307***	0.056		
CER × EA	0.153**	0.054		
Moderated mediation model				
	Effect	BootSE	BootLLCI	BootULCI
Low EA (Mean − 1 SD)	0.0329	0.0327	-0.0312	0.0982
EA (Mean)	0.0794	0.0253	0.0322	0.1329
High EA (Mean + 1 SD)	0.1260	0.0336	0.0632	0.1956
Difference	0.0931	0.0428	0.0129	0.1791

Notes. N = 306; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$. Employees' Perception of Smart City = EPS; Corporate Environmental Responsibility = CER; Environmental Awareness = EA; Employee Green Behavior = EGB.
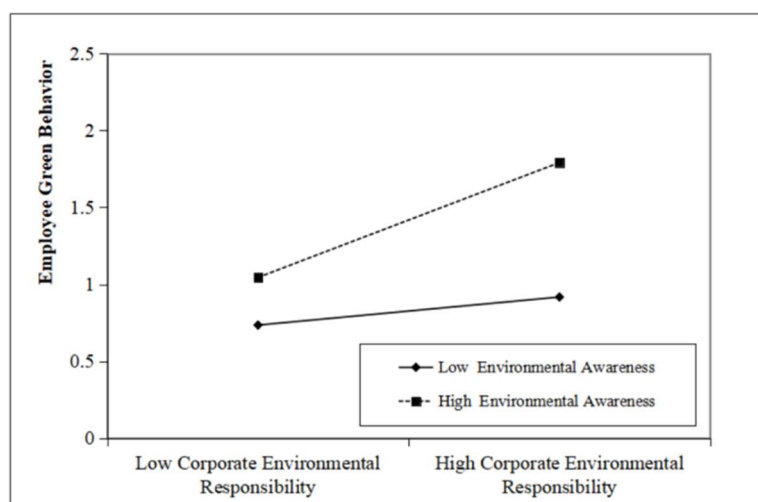

Figure 2. The Moderating Role of Environmental Awareness in Corporate Environmental Responsibility and Employee Green Behavior.

Figure 2 illustrates that elevated environmental awareness correlates with a more pronounced slope change in the relationship between corporate environmental responsibility and employee green behavior. This suggests an intensified impact of corporate environmental responsibility on employee green behavior when environmental awareness is heightened. Environmental awareness is a cheerful moderator of the connection between corporate environmental responsibility and employee green behavior. Furthermore, an increased degree of environmental awareness enhances the affirmative

influence of corporate environmental responsibility on employee green behavior, thereby corroborating the establishment of Hypothesis 5.

Last, to substantiate the validity of the moderated mediation effect (H6), we executed a Bootstrap test utilizing the SPSS25.0 PROCESS plug-in (Model 14), with the outcomes meticulously documented in Table 6. The examination encompassed the evaluation of the conditional indirect impact of the employees' perception of smart city on employees' eco-friendly behavior through organizational green responsibility (this was conducted across three distinct tiers of environmental awareness: One standard deviation above the mean and one above and below the mean for the school number ring). As detailed in Table 6, the observed indirect effect lacked statistical significance (Effect = 0.0329, 95% CI [−0.0312, 0.0982]). The confidence intervals for the lower levels of environmental awareness encompassed 0, underscoring the non-significance. However, the effect achieved significance (Effect = 0.1260, 95% CI [0.0632, 0.1956]) for higher levels of environmental awareness. Notably, the confidence interval denoting the contrast between the higher and lower environmental awareness levels spanned [0.0129, 0.1791]. This observation underscores a noteworthy moderated mediation effect, effectively establishing the legitimacy of Hypothesis 6.

5. Findings and discussion

We aim to analyze and elucidate the influence mechanism of the employees' perception of smart city on employees' environmentally conscious behavior. Our findings demonstrate that the perception of smart city positively impacts employees' green behavior and corporate environmental responsibility. Additionally, corporate environmental responsibility positively influences employees' green behavior. Concurrently, the employees' perception of smart city positively affects employees' green behavior through the intermediary function of corporate environmental responsibility.

Moreover, environmental awareness serves a dual role: it not only serves as a positive regulatory factor in the relationship between organizational green responsibility and employees' green behavior but also effectively regulates the intermediary function of organizational green responsibility in bridging the connection between the perception of smart city and employees' environmentally conscious behavior. Furthermore, environmental awareness assumes a positive moderating role not only between corporate environmental responsibility and employee green behavior but also in effectively moderating the mediating function of corporate environmental responsibility between the employees' perception of smart city and employee green behavior.

5.1. Theoretical contributions

In a broad sense, this paper makes significant theoretical contributions across several dimensions. First, within urban development, the smart city concept stands as a noteworthy trend, seamlessly integrating into daily life and work and profoundly impacting the sustainable advancement of urban centers. Existing studies have predominantly examined the conveniences and challenges arising from the digitalization and informatization of urban progress [1,9], as well as the implications of the smart city paradigm for corporate operations [17]. However, exploring this specific facet concerning the influence mechanism of the smart city on employees' environmentally conscious behavior remains underexplored in current scholarship.

Given the context of intelligent urban evolution, businesses and employees wield escalating significance in steering the trajectory toward eco-friendly development. In this paper, we set out to address this research gap and engage in an in-depth investigation of the influence mechanism of the employees' perception of smart city on employees' environmentally conscious behavior. Anchored in the self-determination theory, we delve into the intricate dynamics. It substantiates that the employees' perception of smart city not only positively impacts employees' green behavior but also indirectly fosters such behavior through the intermediary role of organizational green responsibility. In essence, the diffusion of the perception of smart city within corporate environments propels and reinforces employees' adoption of eco-friendly behavior at work and in their personal lives. Simultaneously, when corporate green responsibility is emphasized within the organizational framework, employees attain a heightened understanding of the significance and necessity of the smart city concept. This, in turn, encourages the organic practice of environmentally conscious behaviors within their work and personal spheres while concurrently diminishing wasteful resource usage and environmental pollution.

Notably, existing research needs to adequately scrutinize the mediation of organizational green responsibility in the relationship between the perception of smart city and employees' environmentally conscious behaviors. Consequently, this paper is a valuable supplement to and extension of previous scholarly work in this domain.

Second, we reveal that environmental awareness assumes a dual role: It positively regulates the correlation between corporate environmental responsibility and employee green behavior and effectively moderates the mediating function of organizational green responsibility in the nexus between employees' perception of smart city and employee green behavior. Environmental awareness, encompassing an individual's cognition and attitudes towards environmental matters, is pivotal in shaping individual behavior within organizational green responsibility.

When employees possess a heightened environmental awareness and actively prioritize environmental concerns, they are more inclined to comprehend and align with the organization's green responsibility, thereby participating more vigorously in eco-friendly practices. In this context, environmental awareness operates as a moderating agent, fine-tuning the relationship between individual environmental attitudes and organizational green responsibilities, thus impacting the manifestation of environmentally conscious behaviors.

Furthermore, under the sway of the smart city concept, enterprises' green responsibilities can impact employees' eco-friendly behavior by kindling their internal environmental awareness. Environmental awareness assumes a crucial intermediary role in this progression, orchestrating the interplay between organizational green responsibility and employees' conduct. By elevating employees' comprehension of corporate green responsibility, an organization may evoke a heightened environmental awareness throughout its workforce, consequently inspiring greater engagement in green practices. Simultaneously, this elevated environmental awareness can heighten employees' recognition of the organization's green responsibility, encouraging their participation in eco-friendly behaviors. In essence, the higher an individual employee's level of environmental awareness, the more pronounced the indirect link between the employees' perception of smart city and the influence of green behavior on employees, facilitated by the organization's green responsibility.

Significantly, the moderating role of environmental awareness within this process has not been systematically explored in the existing literature. As such, this paper is both a supplementary and expansive contribution, building upon prior research in this domain.

5.2. Practical insights

This study bears crucial implications for managerial practices within business organizations. Primarily, it demonstrates that the pervasive dissemination of the smart city concept wields a direct and markedly positive influence on employees' environmentally conscious behaviors. The smart city concept substantively encourages green behaviors by actively stimulating employees' intrinsic behavioral motivations, providing avenues for eco-friendly actions and fostering alignment between employees and environmental awareness.

Moreover, this study posits that corporate environmental responsibility is a mediating factor in the association between the smart city concept and employees' environmentally conscious behaviors. Consequently, when channeled through corporate environmental responsibility, the perception of smart city exerts an indirect yet constructive influence on employees' green behaviors. This finding serves as a reminder for corporate leaders to fortify their internal strategies for green development through varied channels and multifaceted approaches in their daily management endeavors.

Corporate environmental responsibility, positioned as a pivotal strategic orientation, establishes a corporate identity underscored by environmental responsibility and embodies an internal mission. This, in turn, augments employees' environmental awareness within the organization and guides them toward more actively embracing eco-friendly behaviors. In essence, corporate managers are urged to recognize that corporate environmental responsibility transcends a mere façade, emerging as a potent influencer that fosters environmental consciousness and positive engagement with green behaviors among the workforce.

Moreover, this study posits that environmental awareness regulates the indirect connection between the employees' perception of smart city and its influence on employees' green behaviors, facilitated by corporate environmental responsibility. Heightened individual environmental awareness corresponds to a more robust indirect relationship between the smart city perception and its impact on employees' green behaviors via corporate environmental responsibility. This underscores the significance of managerial attention towards fostering and championing green behaviors among employees. Furthermore, it highlights the importance of integrating environmental protection principles into corporate culture and bolstering green management practices. These concerted efforts are essential for realizing the shared objectives of sustainable green development for enterprises and their workforce.

5.3. Research Limitations

Despite the above achievements of this study, there are at least three aspects needed to be improved.

First, this study has limitations in both the process of data collection and the sample of data collected. The data collected and analyzed in this article mainly comes from a specific region, which undoubtedly introduces regional biases to the study. In the context of globalization, various cultures and different regional environments may have significant impacts on employees' knowledge and behaviors. Therefore, the employees' understanding towards smart cities may vary between regions, and our conclusion may consequently be unsuitable when in a different environment or region.

Second, the research methodology of this study has certain limitations. This article adopts a quantitative research method to explore the relationship between the employees' understanding of

smart cities and their green behaviors, while it may overlook some qualitative factors. In this case, the quantitative method adopted may be unable to capture the non-numerical, more detailed and possibly more in-depth information.

Third, the variables selected in this study are not comprehensive enough. This article mainly focuses on the moderating effect of environmental awareness on the relationship between the employees' understanding of smart cities and the employees' green behavior. However, there may be other mediating or moderating variables, such as organizational culture and employees' skills that may also play an important role in this relationship, and these variables have not been fully examined in this research.

5.4. Future prospects

Future researches can start from the following points and then conduct in-depth exploration.

First, study in the future can expand the cultural and regional backgrounds. In order to obtain a more universal conclusion, future research should consider adding a wider range of regions and cultural backgrounds into the data sample. For example, comparing companies from different countries and cultural backgrounds to explore how cultural differences will affect the relationship between employees' understanding of smart cities and their green behavior.

Second, diversified research methods can be used. In order to overcome the limitation of quantitative research, future research can consider combining qualitative and quantitative research methods. Qualitative research methods such as in-depth interviews and case studies can help us better understand employees' perception, cognition and their interpretation of smart cities, thereby providing richer and deeper insights.

Third, future study can explore other mediating and moderating variables. For instance, organizational culture, employee's skills and knowledge can be examined to further improve the relationship model. In addition, other relevant variables such as technology acceptance and organizational support can also be explored, which may play an important role in the model.

Fourth, long-term follow-up research can be conducted to better understand the long-term impact of the employees' understanding of smart cities on their green behavior. Future research can keep tracking in a longer term on the same batch of samples. This can not only come to a more stable and convincing conclusions, but also provide more long-term management strategies and suggestions to the enterprises and governments.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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