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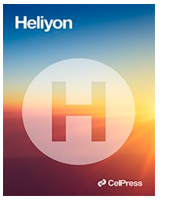

Research article

What determines the batteries recycling behavior of e-bike citizens in Guangzhou?: Integrating place identity and environmental concern into the extended norm activation model

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ABSTRACT

Battery recycling is viewed in China as an important means of achieving primary sustainability goals and greater economic and environmental development. With the notice of high battery recycling intentions through relevant investigations, this study examine the influencing factors of these recycling behaviors of e-bikes citizens by incorporating the place identity and environmental concern into the Extended Normative Activation Model (NAM), which fill the research gap on how place identity and environmental concern affect the batteries recycling behavior. This study proposes that the consequence awareness, personal norms, and attitudes have mediating effect on place identity to the recycling behavior, and the environmental concern has moderating effect on consequence awareness, personal norms, and attitudes to the recycling behavior, respectively. Based on 1068 valid surveys, hypotheses were examined using partial least square structural equation modeling (PLS-SEM). The results show that personal norms and awareness of consequences positively impact e-bike users' intentions to recycle waste batteries, and environmental concerns have no moderating effect on attitude, recycling intention, personal norms, and recycling intention. Theoretical and practical implications are discussed at last.

1. Introduction

Recycling is an efficient and sustainable way of reducing our influence on the environment and is a key factor in implementing successful waste management [1]. Regulations to promote recycling have been proposed in countries around the world to reduce pollution, save resources and energy, and reduce landfill space [2,3]. With the rapidly growing economy of China, the production of municipal solid waste reached 4.78 billion tons by the end of 2022.[1] Many cities have initiated recycling programs and incentive regulations to encourage recycling [4]. The government wants to standardize recycling through a series of programs and encourage people to participate regularly, such as mandated recycling regulations, competitive recycling pricing, convenience recycling infrastructure and waste separation guidance [5,6]. In recycling programs, the most commonly recycled batteries are from electric bikes (e-bikes). This is because China's social ownership of e-bikes has reached 300 million, becoming the country with the largest number of e-bikes in the world [7]. A large number of e-bike users is a big demand for update aging or old batteries. In 2017, The State Council of China has released projects to promote recycling in 46 cities. However, the public did not show enthusiasm for recycling as often as

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[1] https://www.sohu.com/a/618643857_121626425.

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possible, nor did it have the desired effect [8–10]. Thus, to promote and boost recycling behaviors in every society, the government and relevant studies have noticed individuals' recycling intention and behaviors [11].

Prior research on recycling focused on individual attributes and social and advertising communications, such as e-bike recycling has focused on the impact of different technologies on battery life [12–15], the effective recovery method of batteries [16–18], individual user characteristics [19–21], and social interaction between users and policymakers [22–24], without considering place identity and cognitive processes. Research has indicated that implementation intentions and recycling process visualization can improve the recovery of e-bikes users' behavior [25,26]. Thus, domestic and international studies are proposed to determine recycling intention [27]. Many studies have attempted to use the Theory of Planned Behavior (TPB) to discuss the recycling intention of e-bike batteries from the perspective of traditional psychology. By incorporating environmental concerns and social capital into the TPB, Liu et al. studied the battery recycling in New York, based on the combination of traditional TPB structure and conceptual model of the two new factors [28]. Lou et al. examined the recycling intention for batteries of e-bikes in Tangshan, China, based on TPB with convenience [29]. Yu et al. indicated that environmental advocacy positively affects recycling intention in the extended TPB model [30]. Since recycling behavior is significantly affected by external factors such as environmental concerns and place identity, relevant studies have expanded the TPB model from an internal perspective based on previous studies on TPB [31–33]. In the TPB model, external factors should be considered as the core of the e-bike users recycle behavior influence factor [29].

To address this issue, the norm activation model (NAM) is introduced into the research model of TPB to investigate recycling intention, since norms and behavior can be evaluated in NAM [34]. Previous studies indicated that it was crucial to integrating TPB with NAM to examine the antecedents of environmentally friendly or/and prosocial behaviors [35–37]. To better understanding the e-bike users' battery recycling intentions and behaviors, we propose a conceptual framework by selecting the core psychological constructs in both models. In the pro-environmental behavior literature, the integration of TPB and NAM has been used to investigate the predictors of energy-saving intention and behaviors [36], pro-environmental and prosocial behaviors [27], waste separation behaviors [11], and energy-saving intentions and behaviors [38]. However, the TPB provides a rational-choice model considering the behavior as the outcome of individuals' cost-benefit analysis and thus offers a rational basis for understanding how psychological antecedents contribute to the establishment of human behaviors, and it lacks of the role of nonrational, noncognitive and emotional in forming behaviors. Moreover, single model either in TPB or NAM is not sufficient to understand the environmentally friendly practices, like e-bike battery recycling behaviors. Awareness of consequences (AC) is one of the core factors of the personal norms' precursor in NAM [39]. Hunecke et al. found that awareness of consequences positively affects recycling intention [40]. Place identity is addressed in this study because of individuals' emotional attachment to a place or environment [11]. Environmental concerns are selected to evaluate the recycling intention [11]. According to the instruction to the battery recycling facilities and the regulation to the e-bikes in Guangzhou, the battery recycling is closely related to the place/location feature.[2] Particularly, citizens who near the center of Guangzhou city, have the higher intention of battery recycling.[3] In addition, citizens pay more attention in the environmental issue, and are more likely to choose the battery that can be easily recycled [41,42]. Thus, this study proposes a research model combining place identity and environmental concerns into NAM, to examine the recycling intention of e-bike users in Guangzhou. E-bikes are important for the daily transportation of residents, and this province has the highest numbers of the e-bikes-so as the demand for battery updates-indicating a significantly representative city.

In this study, the norm activation model (NAM) is thus expanded with place feature (place identity, PI) and environmental concern (EC) to investigate the battery recycling behavior of the e-bikes in Guangzhou, where NAM is selected to evaluate citizens' norm and behavior. According to NAM, the recycling intention precursor factors are personal norm (PN) and awareness of consequences (AC). Due to its casual implications between AC and intention as well as behavior, induced by Theory of Planned Behavior (TPB), attitudes (ATT) is selected in the proposed model to investigate effect of ATT to intention. Followed by Nketiah et al. [11], EC was chosen to be the moderating variable because it is seen as a necessary factor in this transition, and used to examine the moderate effect between PN, AC, ATT and intention. This study addressed PI because of an individual's emotional attachment to a place or environment since the citizens in Guangzhou had higher intention of battery recycling compared with other districts in China according to the preliminary survey. Thus, our research attempted to address the following research questions.

RQ1. How does the external factor (place identity, PI) affect the citizens' attitude, awareness of consequence and personal norms towards the e-bike battery recycling, which in turn influence the recycling intention and behavior?

RQ2. How does the internal factor (attitude, awareness of consequence and personal norm) determine the battery recycling intention and behavior?

RQ3. How does the environmental concern moderate in the path from the internal factor to the battery recycling intention and behavior?

This study outlines the gap by developing a new research model of incorporating PI and EC into NAM, to examine the influence of PI as well as EC and NAM on the battery recycling intention of e-bikes in Guangzhou. Our study might contribute to the existing literature, especially in recycling behavior settings, in some ways. First, it enhances prior studies to gain a better comprehension of the connection between NAM, PI, EC, and other factors from both internal and external perspectives. The external factors of place identity and environmental concerns are incorporated into NAM, and the proposed new model is extended from internal and external perspectives

[2] Regulations to the e-bikes of Guangzhou, https://www.gz.gov.cn/zwfw/zxfw/jtfw/content/post_9305389.html. 2023-11-14.
[3] Instruction to the battery recycling facilities in Guangzhou, http://gxj.gz.gov.cn/gkmlpt/content/8/8455/mpost_8455056.html#96.

to forecast the s users' recycling intention; Second, it reveals new pathways in moderating the effect of influencing factors with recycling intention. This study examined the moderating effects by setting environmental concerns as the moderating variable between personal norms, awareness of consequences, attitude, and recycling intention, and the results show that environmental concerns only exhibits positive moderating effects from awareness of consequences to intention; these findings are considerably inconsistent with those in previous studies [43–45]; Third, it provides additional proof on how NAM and other influencing factors forecast recycling intention. In this paper, the influencing mechanisms of place identity, personal norms, awareness of consequences, and attitude to the recycling intention are explained, and the mediating effects of personal norms, awareness of consequences, and attitude between place identity and recycling intention are examined. The novel results found no mediating effect from place identity on recycling intention when setting attitude as the mediating variable, which is inconsistent with prior studies [27,46,47].

This paper is organized as follows. We reviewed the literature in Section 2. The hypotheses and research framework are proposed in Section 3. We introduced the measurements and data collection in Section 4, and analyzed the data and obtained findings in Section 5. Finally, we concluded the paper and provided a discussion in Section 6.

2. Literature review

2.1. E-bike battery performance

E-bikes consume less energy and are the most environmentally friendly vehicles among e-bikes [48]. Riding an e-bike can reduce physical exertion while promoting the health of cyclists. With the increasing number of e-bike users, people are paying increasing attention to the battery performance and battery safety of e-bikes [49,50]. Bui et al. proposed an energy monitoring system to deal with range anxiety caused by battery capacity [51]. In order to make the performance of e-bike batteries better, Corno et al. designed a bike-sharing system that can be charged sustainably [52]. For the e-bike sharing system, an important factor affecting the successful operation of the system is whether it can be replaced by changing the battery to replenish the power of the e-bike [12,53].

2.2. E-bike battery life

The factors that affect the battery life of e-bikes have been focused on by a stream of literatures [16,54,55]. As battery life is related to the long-term operating costs of users, it is a key parameter to measure quality. Extending battery life reduces the environmental impact of battery life [7,56]. The life of e-bike batteries is not only related to the battery production technology, but also to the user's daily use mode [12]. Inarguably, the speed of lead-acid batteries aging is affected by the change of acid concentration, too low or too high saturation of the membrane, overcharge, and too high temperature [14,57]. Users should also protect the e-bike when using it, such as reasonable charging and discharging, and maintain a moderate speed [7].

2.3. Recycling of the E-bike battery

The two most important factors that prevented respondents from participating in battery recycling are insufficient knowledge and information about recycling, and the inconvenience of recycling [58–61]. The enthusiasm of recycling has been dampened by the continued low prices of metals in recent years. Some recycling companies and scavengers only collect the most profitable part of used batteries and discard the rest to make a profit; this not only wastes resources but also causes pollution [16]. Providing various recycling methods to meet the needs of different people can greatly improve the convenience of implementing recycling activities, such as providing on-site recycling services for the elderly with mobility problems and online booking recycling services for busy office workers. The key factor of residents in higher recycling intention is the convenience, which proposed by the government or recycling company [62]. The law should make it mandatory for the government to educate the general public and recycling stakeholders about the proper disposal of used lithium batteries so that the public is aware of the dangers of used lithium batteries and acquire knowledge of recycling them. Researchers have attempted to apply the Internet to battery recycling systems while incorporating other approaches to improve the currently available recycling approaches [63].

2.4. Attention to recycling practices

In the waste lead-acid battery management system, individual recycling is of great significance. An increasing number of scholars have begun to study recycling behavior; however, the attention provided remains inadequate [58]. Sun et al. surveyed residents in Dezhou City and Zibo City, Shandong Province, about their knowledge of waste battery recycling, including socio-economic characteristics, consumer behavior of collecting waste batteries, awareness of the harmful effects of chemicals, and knowledge of relevant government policies [64]. Personal awareness of recycling lead-acid batteries is generally not high, mainly because individuals do not understand the consequences of mishandling of waste lead-acid batteries and the management policy of used lead-acid batteries in living areas [58,64]. At the same time, the cooperation between departments is insufficient, and the informal recycling department has a negative impact on the formal recycling department in the process of recycling waste lead-acid batteries [65]. Relevant researchers have suggested that the government should propagandize the knowledge of recycling waste e-bike batteries to make residents realize the harm of waste lead-acid batteries, creating a social atmosphere of green and environmentally friendly. Simultaneously, increasing subsidies to the formal recycling sectors and implementing incentives, such as "replacement," are essential for the implementation of garbage classification activities [58,64,65].

2.5. Policy for recycling waste batteries

In total, 21 countries in the European Union have formulated regulations or laws on the management of waste batteries[4] that require all battery products to be recycled, and manufacturers and retailers are responsible for the recycling and disposal of waste batteries. In Canada, battery management takes place at the provincial level. They implemented the Call2Recycle management plan.[5] From 1994 to 2014, 95 % of the North American battery collection market share was captured by Canada.[6] The recycled waste batteries are shipped to battery recycling companies to produce new batteries, iron products, or cement.[7] To achieve the goal of "zero waste" in the United States, California and New York may issue statewide bans on the disposal of rechargeable batteries in the near future, requiring the collection and recycling of waste batteries [66,67].

However, such mandatory measures have not yet been implemented in China. The number of e-bikes in China is very high, and improper disposal of waste e-bikes will cause serious pollution. Therefore, the government attaches great importance to recycling waste e-bike batteries. However, the overall recycling rate of waste e-bikes in China is less than 60%, mainly due to the inadequate implementation of environmental laws and regulations, the pursuit of economic benefits by enterprises, and the insufficient public awareness of recycling waste batteries [68].

Previous studies have shown that researchers have made many achievements in the battery and battery recycling of e-bikes; however, the following shortcomings have been found. (1) The research on waste battery recycling mostly focuses on the improvement of battery technology, waste battery recycling methods, and battery life but lacks research on recycling behavior; in a few studies on recycling behavior, most researchers briefly analyze the factors that influence recycling behavior of individual waste lead-acid batteries by using econometric models; NAM is widely used in explaining energy-saving behavior [69]. NAM is used to study intention, a momentarily and important determinant of behavior [70]. Therefore, NAM should be employed to license the recycling behavior of e-bike users. (2) The existing studies rarely combine place identity with the NAM model. People's place identity is a portion of their personality related to the place, which reflects the emotional connection between people and the outside world. These places greatly affect the generation of people's identity [71]. Therefore, place identity is added into the model as a variable in this study. (3) There are few researches on the psychology behind the recycling behavior of e-bikes users by using TPB. Consciousness plays a major role in human behavior [72]. TPB can help researchers analyze the factors influencing changes in human consciousness and behavior [73]. Therefore, using TPB is crucial in studying the psychological mechanism of residents' behavior of recycling waste batteries of e-bikes [29]. Furthermore, a few studies have combined the TPB model with the NAM model. This study incorporated the TPB model into the NAM model to form an extended NAM model, which can comprehensively analyze the psychological mechanism behind the recycling behavior of e-bike users (4) Less research has involved the regulatory role of environmental concerns in the recycling scenario of waste batteries for e-bikes. Research regarding the link between residents' pro-environmental behaviors and environmental concerns are available and has discovered that environmental concerns will bring about a positive impact on recycling intention [74]. Some authors have suggested that the moderating factor for information processing may be environmental concerns [38]. In the research on residents' willingness of recycling waste e-bike batteries, we examined the regulatory role of environmental awareness in the extended NAM model.

3. Hypotheses and models

3.1. Place identity

Place identity indicates a citizen's identity as it relates to their physical surroundings; it is a collection of thoughts, preferences, beliefs, sentiments, values, objectives and behavioral inclination towards a physical setting [75]. Cachero-Martínez considered place to be something made up of social significance accumulated by history, as well as a potential source of identity [76]. This means that active and recursive processes related to location and identity, not just location somewhere, should also be examined. Familiarity with the place affects the understanding of the place. The sense of place identity will affect the individual's familiarity with the place [77,78]. In this study, the citizens' ideas and psychological thinking toward the location over time and giving symbolic connotations to that location are taken into consideration [79]. Previous studies have shown the significance of place identity in promoting people's responsible behavior toward ecology [80], and place identity has positively influence between intention and environmental protection efforts [81], in addition, the place identity of farmers has an important influence on ethics and water-saving intentions [71,82]. A high sense of place identity may lead to a higher understanding of the recycling policy of the place, which is conducive to the perception of participation in recycling activities and the enhancement of recycling intention [79]. Consequently, in this study we propose the following hypotheses.

H1. The place identity of e-bike users positively influences their attitudes.

H2. The place identity of e-bike users positively influences their awareness of the consequences.

[4] Reportontheportablebatterycollectionrates-UpdateDec-14-fullversion_LUadded.pdf (epbaeurope.net).
[5] http://www.call2recycle.ca/recycling-law-map.
[6] http://www.call2recycle.org/2014-collections-summary.
[7] http://www.call2recycle.org/battery-video.

H3. The place identity of e-bike users positively influences their personal norms.

3.2. Moderating role of attitude, personal norms, and awareness of consequences

The norm activation model (NAM) was first proposed by Schwartz to explore the factors that affect individual's behaviors from the perspective of altruism [35], and was widely used in explaining pro-social behaviors, particularly in environmental-friendly behavior [11,15,40,80]. In NAM relevant studies, personal norms and awareness of consequences were regarded as the important factors determining intention/behavior [35,83–88].

Researchers have found that personal norms are the antecedents of intention and behavior [89]. Residents' willingness to reduce food waste is positively influenced by personal norms, which means that consumers' increased personal norms for saving food led to increased intentions to reduce food waste [90]. Personal moral standards greatly affect people's environmental protection intentions and behaviors [91,92].

NAM also mentions that when people are aware of the consequences of a particular behavior, their sense of moral makes them more inclined to bear the consequences of things; thus, they may act to avoid negative outcomes [40]. Household customers realize that the negative consequences of household food waste led to a higher willingness to reduce food waste, and correspondingly, they take action to reduce food waste [93]. Wan et al. found that recycling intention would be affected by awareness of consequences [94]. Nketiah et al. noticed that awareness of consequences has a significant impact on citizens' willingness to invest in projects that convert urban domestic waste into energy [11].

Besides, attitude is so crucial that researchers have studied attitude in combination with other theoretical structures of waste management, and more attention has been paid to "knowledge, attitude, and practice." [95,96]. The so-called attitude is a person's positive and negative evaluations toward a certain behavior [97]. In other words, it refers to e-bike users' views on recycling. Whether an e-bike user is willing to recycle waste batteries is related to his or her recognition of this matter. In accordance with several studies, the most important factor in environmental behavior is attitude [98,99]. Attitude affects the generation of garbage and is critical to manage solid waste effectively [100]. Several recent studies have shown that attitude has a profound influence on environmental intentions [101,102], and the attitude has a significant impact on the willingness to recycle [28,79,103]. Moreover, the analysis of recycling intention behavior is deeply influenced by attitude [35,41,104,105].

In this study, we therefore consider attitude, awareness of consequence and personal norm as the moderating factors, and examine the moderating effect between attitude, awareness of consequence and personal norm and recycling behavior. The following hypotheses are proposed.

H4. E-bike users' attitude has a positive impact on recycling intention.

H5. E-bike users' awareness of consequences positively impacts citizens' recycling intention.

H6. E-bike users' personal norms positively impact citizens' recycling intention.

3.3. Mediation role of the environmental concern

Citizen's comprehension and emphasis on environmental degradation are at the heart of environmental concerns [83], which is related to people's sense of shame when not protecting the environment. Environmental concerns can take the form of an individual's understanding of environmental problems and willingness to take action to address them [60,61]. The main reason why consumers are willing to implement environmentally friendly behavior is environmental concerns [37]. Previous literature suggests that good environmental concerns predict environmentally friendly behavior [104]. A vital moderator of persuasive information elements is the environmental concern [38].

Environmental concerns enhance the positive impact of consequence awareness on recycling intention. The coronavirus pandemic has prompted consumers to consider sustainability and environmental friendliness more when consuming, indicating that consumers' awareness of consequences has increased [63]. The influence of sustainable producers' trust on sustainable purchasing intentions is positively moderated by environmental concerns [37]. One of the moderators of residents' purchase intentions is the environmental concern [76,106]. In other words, environmental concerns are related to people's awareness of environmental issues.

Environmental concerns include attitude related to the environment [105]. Therefore, from the definition of environmental concerns, it is related to attitude. Environmental concerns regulate the relationship between attitude and brand preferences [60]. When people show a high level of environmental concerns, they have a more positive attitude toward eco-friendly advertising and have a greater incentive to carry out the proposed behavior. That is, environmental concerns have a positive moderating effect on attitude and behaviors [38]. The relationship between attitude and behavioral intentions can be mediated by environmental concerns. When attitude toward organic products is positive, customers who have more environmental concerns are more willing to engage in environmentally friendly behavior [76].

Environmental concerns play an active intermediary role in personal norms and recycling intention. One of the important research directions for the willingness to implement sustainable behavior is to explore the moderating role of environmental concerns [63]. Previous research has supported the connection between environmental concerns and personal norms and believed that environmental concerns affect environmentally friendly behavior through personal norms [107–109]. Understanding farmers' moral obligations in specific environmental actions can lead to a better understanding of their intentions [91]. The key to successfully promoting environmental intentions is the development of farmers' personal norms [91].

The moderator variable can regulate the influence of antecedents on consequences. When the moderator variable plays an active regulatory role, the more active the regulatory variable is, the more positive the antecedents will be on the consequences [110]. This study considered environmental concerns as a control variable to the model for research, and the hypotheses are proposed as follows.

H7. E-bike users' environmental concerns have positively moderating effect on attitude and recycling intention.

H8. E-bike users' environmental concerns have positively moderating effect on awareness of consequences and recycling intention.

H9. E-bike users' environmental concerns have positively moderating effect on personal norms and recycling intention.

Based on the above assumptions, we have the conceptional research framework in Fig. 1.

4. Materials and methods

4.1. Data collection

The survey data of Guangdong Province was adopted to verify the hypothesis. The structures were potential, requiring the scaling of multiple measurement items and developing a questionnaire [27]. The questionnaire has three parts: demographic data, deciding variables, and recycling intention. Users of e-bikes aged 18 years and above in Guangdong Province were requested to answer the questionnaire. A pilot trial was held, and 232 people responded to the survey in November 2022. Once ambiguous wording was resolved, the questionnaire was finalized and distributed online. The comprehensibility and validity of the questionnaire were tested before data collection. Eventually, 1278 responses were received. By deleting meaningless answers and unqualified questionnaires with response times of less than 40 s, 1068 valid samples were returned for analysis.

To ensure the sample size is efficient to carry out this study, we calculate the minimum sample size necessary for this investigation followed by Babbie [111] and Duong [112]. It assumed an equal likehood of positive and negative attitudes among the citizens. Based on the methodology proposed by Sekaran and Bougie, the Z-score of 1.96 is adopted in this study. The minimal sample size is calculated in the confidence level of 95 % in the following formula:

$$N = \frac{Z^2 p(1-p)}{e^2} = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2} = 384$$

The minimal acceptable number of sample data was 384, while our valid sample comprised 1068 observations. As a result, the sample is appropriate for further analysis.

As shown in Table 1, 52.06 % of the participants were female. The largest proportion of participants were aged 26–35 years (53.37 %), followed by participants aged 36–45 years (25.66 %) and people aged 46–55 years (14.79 %). The age brackets of the leftover replies were aged under 25 years (4.4 %) and above 56 years (1.78 %). Most participants were middle-aged. The respondents were composed mostly of people with bachelor's degrees. Except for this, the proportion of participants with a college degree or below (9.64 %), a master's degree (12.83 %) and a doctorate degree (14.89 %) accounted for a small proportion. Regarding occupation, a significant number of respondents were enterprise staff, followed by enterprise managers (19.38 %) and other occupations (9.74 %), and the least were working under institutions (2.62 %). Approximately 35.21 % of respondents earned between 7051 and 10,000 RMB and 29.49 % people earned between 5001 and 7500 RMB. A total of 22.38 % of the participants had an income under 5,000 RMB, and 12.92 % ranged above 10,000 RMB.

4.2. Measurements

This study collected data through a questionnaire consisting of seven parts. With responses from e-bike users in Guangdong province, this study analyzed the factors that affect the participants' intention of recycling waste e-bike batteries and solve the research problems. The indicators investigated included the original constituent of the NAM, attitude, place identity, recycling intention, and environmental concerns. In the first part of the questionnaire, the interviewees should provide demographic information such as

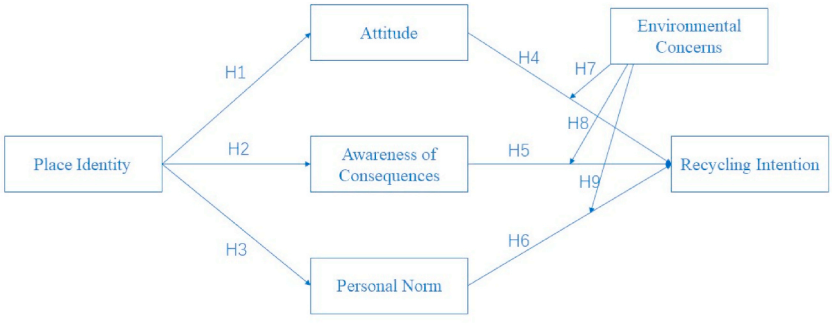

Fig. 1. The framework of the study.

Table 1
Characteristics of respondents.

Variable	Category	Frequency	Percentage/%
Gender	Male	512	47.94
	Female	556	52.06
Age	Under 25	47	4.40
	26–35	570	53.37
	36–45	274	25.66
	46–55	158	14.79
	Above 56	19	1.78
Education	College or below	103	9.64
	Bachelor	669	62.64
	Master	137	12.83
	Doctorate	159	14.89
Occupation	Enterprise staff	729	68.26
	Enterprise manager	207	19.38
	Work under institution	28	2.62
	Other	104	9.74
Income level	below 2500	201	18.82
	2501–5000	38	3.56
	5001–7500	315	29.49
	7501–10000	376	35.21
	Above 10,000	138	12.92

gender, age, work status, education level and income level. Except for the first section, the remaining sections evaluated the survey items using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The second part is the attitude scale of e-bike users, referring to previous studies [15,94,99]. The next two parts were the original components of the NAM, namely, personal norms and awareness of consequences. These two parts were modified based on previous research on recycling intention [113–115]. The three above-mentioned factors comprise an extended NAM for analyzing recycling intention. By consulting relevant studies [79, 115], the fifth part of the place identity scale was formed through modifications. Chapter 6 is the scale of environmental concerns for e-bike users, referring to Dhir et al. [7,63]. The last chapter is the recycling intention scale of e-bike users, which draws on existing studies [116,117].

To address common method variance (CMV) during the process of modifying the initial scales, developing questionnaire, and recruiting participants, two stages were employed in this study. First, the back-translation technique was used to eliminate the effect of CMV, in which 27 items from six constructs were translated into Chinese by language specialist, who then generated a Chinese version of the questionnaire. Another professional researcher then translated the questionnaire from Chinese into English, to ensure the absence of bias in language translations. Secondly, the six constructs were arranged in a certain sequence to reduce the potential impact of CMV in the pre-investigation and formal investigation.

4.3. Statistical analysis

This study intended to explore the relationship among attitude, awareness of consequences, personal norms, place identity and recycling intention of e-bike users. The data analysis for this study were conducted utilizing SPSS 23.0 and PROCESS macro. Firstly, similar with Duong [118], the description statistics such as the normal distribution was tested before testing the hypotheses [35]. The frequency, skewness and kurtosis of the constructs ATT, PN, AC, PI, EC and INT were computed. Secondly, to ensure the reliability and validity of the scales in this study, we calculated Cronbach's alpha of each variable. Additionally, we conducted Fornell-Lacker criteria to confirm the discriminant validity of the variables, which followed by Hair et al., [119]. Harman's single factor modeling was deployed to test the presence of CMV [118]. Finally, followed by the relevant studies, we used PROCESS macro to test the mediating, moderating and conditional effects [35,120], since Structural equation model (SEM) has some limitations in terms of testing moderated mediation coefficients [107,108]. In our study, PROCESS macro with custom model setting (/bmatrix = 1,1,0,1,0,0,0,1,1,1, /wmatrix = 0,0,0,0,0,0,0,1,1,1) was thus utilized to examine the mediating effect of EC, whereas moderated mediating analysis was conducted utilizing the same custom model to examine the moderated mediating effect of ATT, PN and AC. Based on a random sample numbering 5000, bootstrapping with 95 % confidence intervals was used to estimate the statistical significance of association of the proposed custom model.

5. Results and analysis

5.1. Measurement model analysis

Relevant studies indicate that reliability (composite reliability, CR), Coronach's alpha (α), discriminant validity (average variance extracted, AVE), and convergent validity (indicator reliability) must be examined for achieving the statistics standard in the study. The consistency and stability of the test results is called the reliability of the data, and the reliability test is widely applied Cronbach's alpha [109]. If $\alpha \geq 0.7$ and $CR > 0.6$ are considered sufficient and acceptable. This study supported reliability. All concept measures had

factor loadings above 0.7 and AVE values above 0.5, indicates that the convergent validity is acceptable.

Each observed variable of the higher-order structure was substituted from lower-order structures. The lower-order constructs' path coefficients were transformed into factor loadings. Loadings on the lower-order structures were more than 0.7, and the findings indicates the dependability of the indicators. The reliability and validity of the higher-order construct must be determined by utilizing different indicator loadings and their association with the lower-order components. CR, α, and AVE of each variable were higher than the recommended rule. The validity and reliability are summarized in Table 2.

Similar with [119], the discriminant validity was deployed by employing Fornell-Lacker criteria to ensure each concept be different and represents phenomena not captured by other paradigms in the model, and the construct correlations to the square root of AVE is compared in Table 3.

5.2. Model for structures

Structure Equation Model is used to evaluate and determine the proposed model's forecast capabilities and relevance of the hypothesized paths. In this study, a bootstrapping approach with 5000 samples in the PROCESS macro was used to assess the relevance of predicted hypothesized paths. The importance of standardized root means square residual (SRMR), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and root-mean-square error of approximation (RMSEA) as model fit are presented in Table 4. A Harman's single-factor analysis with unrotated solution reported an explained variance of 27.819 % < 50 % [121], which confirm the absence of CMV in our study [118].

Following the study of Duong et al. [112], a p-value of less than 0.05 indicates statistical significance, and the coefficient of determination (R^2) for endogenous variables determines the model's predictive power [118]. In the model fit examination, an R^2 value of 0.685 for the six-factor model is regarded to have a significant effect. The R^2 is shown in Table 5.

5.3. Hypothesis test

The results of the hypothesis indicate that among the nine hypotheses in this study, the *P* value of H1, H2, H3, H4, H5, H6, and H8 is greater than 0.05; thus, these two hypotheses are not supported. In Fig. 2 and Table 6, *P* values < 0.001 are represented as *** and $0.001 \leq P$ values < 0.005 are represented as **. The standardized regression coefficients show that awareness of consequences have the greatest impact on the recycling intention of e-bike users. Every increase of 1 standard deviation in consequence awareness increases 0.502 standard deviation in the users' recycling intention. The personal norms of e-bike users are most affected by place identity. Standard deviation is added to place identity, and the user's personal norms add 0.627 standard deviations. In addition, place identity considerably affects attitude. For every 1 standard deviation increase in place identity, user's attitude increases by 0.622 standard deviations. With the environmental concerns increasing by 1 standard deviation, the standard deviation between the consequence awareness and the recycling intention decreases by 0.134, which means that environmental concerns negatively moderate the relationship between consequence awareness and recycling intention. Furthermore, environmental concerns do not moderate

Table 2
Variable validity and reliability.

Variables	Measurement Items	Factor loadings	α	CR	AVE
ATT	ATT1	0.802	0.911	0.934	0.739
	ATT2	0.843			
	ATT3	0.908			
	ATT4	0.871			
	ATT5	0.871			
PN	SN1	0.898	0.926	0.948	0.819
	SN2	0.888			
	SN3	0.944			
	SN4	0.889			
AC	AC1	0.804	0.905	0.931	0.729
	AC2	0.853			
	AC3	0.893			
	AC4	0.848			
	AC5	0.867			
PI	PI1	0.867	0.908	0.932	0.734
	PI2	0.875			
	PI3	0.887			
	PI4	0.747			
	PI5	0.898			
EC	EC1	0.804	0.844	0.894	0.679
	EC2	0.826			
	EC3	0.915			
	EC4	0.742			
INT	INT1	0.907	0.880	0.926	0.808
	INT2	0.937			
	INT3	0.850			

Table 3
Discriminant validity based on Fornell-Lacker criterion.

No.	Variable	1	2	3	4	5	6
1	PI	0.829					
2	PN	0.669	0.878				
3	AC	0.648	0.506	0.813			
4	ATT	0.672	0.661	0.826	0.827		
5	EC	0.805	0.644	0.578	0.570	0.770	
6	INT	0.817	0.615	0.563	0.572	0.863	0.852

PI= Place Identity, PN=Personal Norm, AC = Awareness of Consequence, ATT = attitude, EC = Environmental Concern, INT= Battery Recycling Intention.

Table 4
Model fit.

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA	SRMR
Six factor Model	817.30	284	2.88	0.91	0.90	0.08	0.05
Five factor model	962.51	289	3.33	0.89	0.87	0.09	0.06
Four factor model	1449.42	293	4.95	0.81	0.79	0.12	0.07
Three factor model	1527.56	296	5.16	0.80	0.78	0.12	0.07
Two factor model	2039.36	298	6.84	0.71	0.69	0.15	0.10
Single factor model	2400.98	299	8.03	0.65	0.62	0.16	0.10

the relationships between personal norm and recycling intention, or between attitude and recycling intention.

Process plug-in component was applied to verify the magnitude of the mediation effect in this study. The direct effect of place identity on recycling intention was assumed to be fixed to 0, and the indirect impact of attitude, personal norm, and consequence awareness on the recycling intention was then tested. If the confidence interval obtained by the bootstrap method contains 0, it is a complete intermediary effect; otherwise, it is a partial mediation effect. The results in Table 6 indicate that awareness of consequences has mediating effects on place identity and recycling intention.

6. Conclusions and Discussions

6.1. Conslusions

(1) Place identity of e-bike users positively influences attitude, awareness of consequences and personal norms.

H1 (*P* Values = 0.000, β = 0.622), H2 (*P* Values = 0.000, β = 0.597), and H3 (*P* Values = 0.000, β = 0.627) are supported, indicating that place identity positively and significantly affects attitude and awareness of consequences. This result is in accordance with previous research. Nketiah et al. stated that the expanded NAM model formed after adding the factor of attitude can transmit a larger number of place identity influences on recycling intention of citizens [11]. Wan et al. stated that place identity plays a significant and positive role in promoting citizens' awareness of ecological responsibility [80].

This study confirms that e-bike users with a higher place identity have stronger personal norms, which implies that they have a tendency to change their recycling intention due to others' opinions. Furthermore, if residents have a deep sense of identity with Guangzhou, they are likely to realize the negative impact of not recycling waste batteries on the environment and society, thus arousing their moral responsibility and increasing their willingness to recycle. At the same time, with the increasing recognition of Guangzhou, the public's attitude towards recycling waste e-bike batteries has become more positive. Residents with profound feelings for Guangzhou are more willing to implement environmental protection behaviors that are conducive to the development of the city.

(2) Attitude, awareness of consequences and personal norms have a positive effect on e-bike users' intention to recycle waste e-bike batteries.

Such a hypothesis indicates that the user's attitude (*P* Values = 0.000, β = 0.523), awareness of consequences (*P* Values = 0.000, β = 0.502) and personal norms (*P* Values = 0.000, β = 0.564) affect their intention of recycling waste e-bike batteries positively and significantly, as confirmed by the study results. This result is in accordance with previous research in the pro-social and pro-environmental fields [63,90,121]. These studies all hold the opinion that recycling intention is positively and significantly influenced by awareness of consequences and personal norms.

Based on the results, the opinions of other important residents affect their recycling intention. Residents' willingness to recycle used e-bike batteries increases if their families, friends and other important people support recycling. This also proved that residents' understanding of the significance of recycling waste e-bike batteries promotes their recycling intention. The more residents comprehend the consequences and advantages of recycling, the likelier they are to practice. These conclusions are consistent with our expectations. Furthermore, the suggestions and expectations of those around them put pressure on e-bike users, who are easily

Table 5
Fitness of the proposed model.

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	PN		AC		ATT		INT					
	b	se	b	se	b	se	b	se	b	se	b	se
gender	0.084	0.079	−0.501*	0.244	−0.022	0.048	−0.018	0.061	−0.021	0.061	−0.008	0.055
age	0.023	0.034	0.037	0.105	0.037	0.021	0.014	0.026	0.010	0.026	−0.002	0.023
education	0.106	0.075	−0.287	0.234	−0.080	0.046	−0.086	0.059	−0.096	0.059	−0.086	0.052
position	−0.041	0.042	0.051	0.130	−0.027	0.026	−0.033	0.033	−0.028	0.032	−0.010	0.029
income	0.000	0.037	0.099	0.114	0.014	0.023	0.029	0.029	0.027	0.028	0.020	0.025
PI	0.698***	0.053	2.047***	0.164	0.432***	0.032	0.723***	0.041	0.584***	0.058	0.347***	0.060
PN									0.153**	0.051	0.061	0.047
AC									0.020	0.019	0.029	0.023
ATT									−0.020	0.019	−0.021	0.114
EC											0.424***	0.054
PN*EC											−0.070	0.072
AC*EC											−0.053	0.031
ATT*EC											0.145	0.171
R^2	0.403		0.384		0.407		0.541		0.563		0.658	
ΔR^2	–		−0.019		0.023		0.134		0.022		0.095	
F	30.214***		27.785***		30.682***		52.650***		37.902***		38.607***	

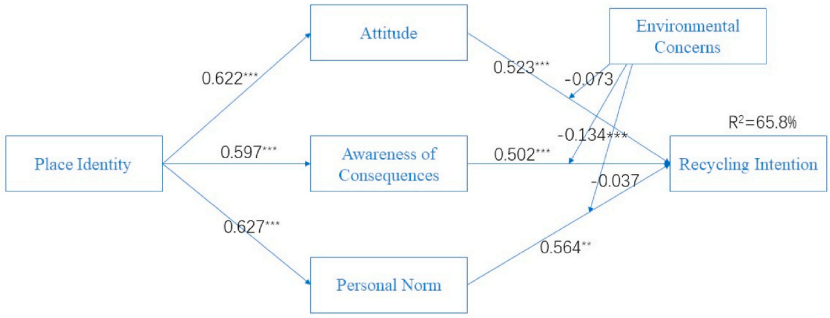

Fig. 2. Standardized output of constructs.

Table 6
Overview result of structural model.

H	Path	Direct effect				Indirect effect			
		β	p	LLCI	ULCI	Effect	Boot Se	LLCI	ULCI
H1	PI→ATT	0.622	0.000	0.361	0.488				
H2	PI→AC	0.597	0.000	1.700	2.347				
H3	PI→PN	0.627	0.000	0.592	0.798				
H4	ATT→INT	0.523	0.000	0.607	0.900				
H5	AC→INT	0.502	0.000	0.116	0.176				
H6	PN→INT	0.564	0.000	0.414	0.588				
	PI→ATT→INT					−0.061	0.050	−0.032	0.162
	PI→AC→INT					0.056	0.047	−0.028	0.147
	PI→PN→INT					0.112	0.055	0.015	0.225
H7	EC*ATT→INT	−0.073	0.094	−0.172	0.014				
H8	EC*AC→INT	−0.134	0.003	−0.230	−0.046				
H9	EC*PN→INT	−0.037	0.343	−0.121	0.042				

influenced by external pressure to increase their willingness to recycle waste batteries. When individuals perceive that not recycling garbage daily has some negative effects, they are more willing to perform the moral responsibility of recycling garbage [39].

(3) Awareness of consequences has positively mediating effect on place identity and recycling intention

From the result of indirect effect in Table 6, we can know that only awareness of consequences has positively mediating effect on place identity and recycling intention (*P* Values = 0.056, β = 0.047), while attitude and personal norm have no mediating effect on place identity and recycling intention. The results of this study show that residents' views on recycling waste e-bike batteries have a minimal impact on recycling intention. People's perceptions of specific behaviors based on their own values are called attitude [27]. This study confirms that e-bike users' willingness to recycle is not affected regardless of their attitude towards recycling. Even if residents think that recycling is a wise behavior that is instrumental in the environment and society, their recycling intention is not enhanced.

(4) Environmental concerns have a significant but negative moderating effect between awareness of consequences and recycling intention.

The result shows that environmental concerns (*P* Values = 0.003, β = −0.134) significantly but negatively moderate the relationship between awareness of consequences and recycling intention. Some previous studies also hold the opinion that environmental concerns play a positively moderating role in the relationship between awareness of consequences and recycling intention [63,75]. This research further proved that this moderate effect is negative, which is different from previous studies. If the environmental concerns of residents are strong, the positive impact of consequence awareness on recycling intention weakens. In contrast, the weaker the environmental concerns of the residents, the stronger the positive impact of consequence awareness on recycling intention. The environmental concerns of citizens in Guangzhou decrease the recycling intention no matter the awareness of consequence is high enough, which are mainly about the education background of the data sample, 62.64 % is bachelor.

(5) Environmental concerns have no moderating effect between attitude and recycling intention, also between personal norms and recycling intention.

The results of this research indicate that environmental concerns do not moderate the relationship between attitude and recycling

intention, or between personal norms and recycling intention. Therefore, H7 (P Values = 0.094, $\beta = -0.073$) and H9 (P Values = 0.343, $\beta = -0.037$) are not supported. No matter how the environmental concerns of e-bike users change, it does not affect the relationship between personal norms and recycling intention or between attitude and recycling intention.

6.2. Discussions and limitations

This paper used the NAM model with attitude to investigate the effect of place identity as well as environmental concerns on recycling intention through a questionnaire. The attitude of e-bike users has significant effect on recycling intention, which is consistency with the findings of previous researches [96,101,102]. These researchers believe that one of the most important factors affecting recycling intention is attitude. The following two reasons may contribute to this result at variance with expectations. First, most of the waste batteries of e-bikes in Guangzhou are recycled and reproduced by peddlers and black workshops, which are in chaos. In addition, they are in the "three neglected gray zones," which means that they have not been written into the law nor supervised by the government or industry associations. The majority of residents are reluctant to contact informal hawkers and are afraid of breaking the law or being cheated on; thus, they are unwilling to recycle. Second, formal recycling outlets are faulty and are still being established by the government. The cost of sending waste batteries to regular recycling outlets is too high, which does not increase the residents' motivation to recycle, even though they have a good attitude toward recycling.

According to the findings, the moderating role of environmental concerns between consequence awareness and recycling intention is negative. However, Tandon et al. believed that the environmental concern is one of the moderators of residents' purchase intentions [106]. The reason for the negative adjustment effect may be that the respondents selected in this study have fewer environmental protection behaviors in Guangzhou, and the environmental protection atmosphere in Guangzhou is weak. The behaviors mentioned in the questionnaire, such as donating money for environmental protection organizations and boycotting the products of non-environmental protection companies, are unfamiliar to the respondents. Therefore, many negative answers are available to these questions, resulting in a negative adjustment between the consciousness of consequences and the willingness to recycle.

This study discovered that in Guangdong Province, the relationship between recycling intention and attitude as well as between recycling intention and personal norms are not regulated by environmental concerns. Unlike Gómez-Carmona et al. who reckoned that environmental concerns positively moderate the relationships between attitude and behaviors, this projected outcome indicates that environmental concerns have nothing to do with the relationship between recycling intention and attitude [38]. The result of this study is also distinct from previous studies that hold the opinion that environmental concerns affect environment-friendly behavior through personal norms [77,78,122]. One cause may be that a large number of respondents in this study are 20–25-year-old residents, most of whom are students. They are not financially independent, indicating that they can bear only low costs when implementing environmental protection behaviors. However, the cost of recycling waste batteries of e-bikes in Guangzhou is relatively high; as a result, objective conditions lead them to be unable to practice recycling waste batteries most of the time, and they do not feel guilty for not recycling. Nevertheless, these people are well educated and have a positive attitude toward recycling. Subjectively, they are also vulnerable to the influence of other people's opinions to enhance their recycling intention. Therefore, the results of this study show that environmental concerns do not moderate the relationship between personal norms and recycling intention, or between attitude and recycling intention.

This study introduced attitude as a newly added factor to construct an expanded NAM model, which is a practical framework that can show the impact of place identity on citizens' willingness to recycle more comprehensively. The results provide new insights into the impact of place identity on citizens' recycling intention. In addition, previous studies have paid less attention to the moderating role of environmental concerns. Hence, environmental concerns have been added as a moderating variable in this research model. This model has found some unique roles of environmental concerns, leading to a more comprehensive analysis of the factors that influence residents' willingness to recycle, thus helping to formulate policies to encourage residents to recycle.

At present, there are a large number of researches on waste batteries of e-bikes; however, most of them focus on improving the battery technically and improving the battery utilization rate, while less attention is paid to the psychological state of e-bike users. Relatively few studies have been conducted on e-bike battery recycling behaviors from a psychological perspective. The psychological factors of e-bike users are very important to the recycling of waste e-bike batteries, which is of great help to managers in formulating relevant recycling policies. Therefore, this study used the NAM model to analyze the factors that affect the recycling intention of e-bike users, which is helpful to enrich the related research content of recycling behaviors of waste e-bike batteries.

There are some limitations in this study. First, the volume of data sample is still less after the second round investigations. Because the e-bike users are increasing in Guangzhou nowadays, it is hard to get more samples for this large party. Second, the concept model can be optimized by setting environmental concern as the determinate factor. In our study, we have found that the moderating effect of environmental concern between awareness of consequence and recycling intention is negatively significant, but the other two moderating effects are not significant. We can set the environmental concern as determinate factor in future study.

Data availability statement

Data are collected from questionnaire through wjx.cn, and will be available when request for the corresponding author.

CRediT authorship contribution statement

Dong Wang: Writing – original draft. **Yifei Xu:** Formal analysis, Data curation, Conceptualization. **Yi Wang:** Data curation,

Conceptualization. **Yujing Chen:** Writing – review & editing, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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