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How Environmental Policy Perception and Social Media Use Impact Pro-Environmental Behavior: A Moderated Mediation Model Based on the Theory of Planned Behavior

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Abstract: Pro-environmental behavior (PEB) is an essential source for solving environmental problems and implementing sustainable development. This study reveals the antecedent mechanisms of PEB from the joint perspective of environmental policy perception (EPP) and social media use (SMU). We developed a moderated mediation model based on the theory of planned behavior (TPB) and tested the hypotheses using questionnaire data from 408 residents in Tianjin, China. The results indicated that EPP positively affects PEB and that attitude and perceived behavioral control in the TPB framework mediate the relationship between EPP and PEB. SMU not only has a positive effect on PEB but also remotely mediates the effect of EPP on PEB together with perceived behavioral control. Furthermore, gender and age have a positive moderating impact on EPP. This study provides the first theoretical and empirical explanation of how EPP influences PEB within a systematic TPB framework while also introducing SMU as an innovative expansion of the explanatory model. This study also provides recommendations for policymakers on environmental management practices.

Keywords: pro-environmental behavior; environmental policy perception; social media use

1. Introduction

Human behavior that damages the environment is the root cause of numerous ecological and environmental problems, and the resolution of these issues inevitably depends on pro-environmental behavior (PEB) [1]. PEB has been confirmed as an essential source for implementing sustainable development [2]. For example, promoting individuals' PEBs are important for the sustainable development of an environmentally friendly city [3]. Consequently, many scholars focus on the antecedent factors of individual PEB [4–7].

Based on the environmental action technology model developed by Ballew et al. [4], the factors that affect individuals' PEBs include three levels. The first level comprises personal factors, including childhood experiences, attitudes, environmental knowledge, etc. [8,9]. The second level encompasses social factors, referring to the impact of other people (perceived or imagined) on the promotion of PEB, such as social status or reputation concerns and subjective norms [10,11]. The third level consists of environmental factors, such as cities, workplaces, policies, and regulations [4,12].

Regarding contextual factors in policies, China currently faces significant pressure to improve its environmental conditions [3]. The Chinese government has acknowledged this challenge and implemented various environmental protection policies, such as waste sorting, low-carbon travel, green communities, and air pollution control [5,13,14]. Recent studies indicate that environmental policy perception (EPP) factors positively influence PEB [12,15–17]. However, except for Wang and Mangmeechai's study [17], the existing literature on how EPP affects PEB remains relatively superficial, merely identifying the presence

of EPP's influence without scientifically elucidating the underlying mechanisms. Okumah et al. [18] suggest that the theory and evidence concerning the relationship between policy factors and PEB require further clarification. Additionally, Wang and Mangmeechai [17] argue that the understanding of the moderating effects of the relationship between policy factors and behavior is limited. Consequently, further research is necessary to address these gaps in the literature.

On the other hand, the proliferation of social media has significantly altered people's daily lives [19]. In recent years, the rapid development of mobile social media has transformed the way users receive information, integrating their online and offline activities and enabling them to exist simultaneously in both physical and virtual spaces [5,20]. Social media use (SMU) also presents considerable potential for promoting pro-environmental activities [20]. The current literature has established associations between SMU and various PEBs, including waste sorting [14], fishery conservation [21], low-carbon actions [7], and comprehensive PEB [5,22,23]. However, studies examining the relationship between SMU and PEB are still in their preliminary stages [23], and there is a particular paucity in the literature addressing the antecedents of SMU and the mechanisms through which it affects PEB.

To address the current knowledge gaps, this study focuses on the following three key issues: First, apart from whether EPP can affect PEB, what is the mechanism behind the impact? Second, does SMU influence the relationship between EPP and PEB, and if so, how? Third, are the effects of EPP moderated by demographic characteristics? To investigate these questions, we employ a moderated mediation model based on TPB to examine the impact of EPP and SMU on PEB using questionnaire data collected from 408 residents of Tianjin, China.

This study contributes novel insights to the literature by extending the TPB framework to explain PEB. Firstly, we examine the impact of EPP factors, which have received increasing attention in the Chinese context, on PEB, and provide the first theoretical explanation and empirical evidence of how EPP affects PEB based on the systematic TPB framework. Secondly, to our knowledge, we are the first to incorporate SMU into the relationship between EPP and PEB and to elucidate its mechanism using the TPB framework. Finally, we also examine the moderating effect of demographic factors on EPP, which compensate for the current limited understanding in this area. Our paper provides valuable insights into the comprehensive understanding of the relationship between EPP and PEB and provides suggestions for policymakers' environmental management practices.

The remainder of this paper is structured as follows: Section 2 provides a brief review of the relevant literature on TPB framework-based PEB, EPP, and SMU, followed by the development of our hypotheses. Section 3 presents the methodology and data sources. Section 4 details the data analysis, modeling calculations, and results. Section 5 discusses this study's findings, and Section 6 concludes this paper.

2. Theoretical Framework and Hypotheses

2.1. Apply TPB to PEB

PEB is currently defined as actions taken by individuals to enhance ecosystem structures by reducing or eliminating the negative environmental impact of their activities [24,25]. To better analyze PEB and understand the factors influencing PEB, researchers have developed numerous models using diverse theoretical frameworks and multidisciplinary approaches from fields such as social psychology, economics, and education [26]. Environmental psychology studies emphasize the following three basic theoretical frameworks to explain PEB and its influencing factors: the theory of planned behavior (TPB), the normative activation model (NAM), and the value belief norm theory (VBN) [27]. Sopha et al. [28] argue that TPB is one of the most frequently applied theories in environmental psychology. TPB is widely employed to explain and predict intentions and behaviors, and to analyze the factors influencing individual behavior [29]. TPB argues that behavior depends directly on the intention to take that behavior, which depends on people's attitudes toward the

behavior, the subjective norms associated with the behavior, and the perceived behavioral control (PBC) [30]. TPB enables us to comprehend the influence of personal determinants, social environment, and non-volitional factors on intention [31]. This theory has been applied to environmental behavior in multiple studies, and its proposed model structure has been supported by the analysis of several past investigations [32,33].

Ajzen hypothesized that intention is the most important predictor of human behavior [30]. An individual's actions depend directly on their intention to perform that behavior. Intention can be understood as reflecting an individual's willingness to exert effort to engage in behavior [32]. A substantial body of research has demonstrated that behavioral intentions can predict individual behavior across various domains [29,34]. Previous studies on environmental or ecological behavior have shown that behavioral intentions associated with specific environmental actions are closely related to actual behaviors [17,35]. Understanding residents' pro-environmental intentions allows for a better comprehension of the processes by which they engage in PEBs. Therefore, we propose the following hypothesis.

Hypothesis 1 (H1). *Residents' pro-environmental intentions are positively correlated with their PEBs.*

TPB argues that the more favorable individuals' attitudes and subjective norms toward behavior, the greater their PBC, and the stronger their intention to act [30]. Firstly, attitudes involve an individual's evaluation of a behavior's good or bad, thus informing their decision to engage in it [36]. In the environmental domain, attitudes are conceptualized as cognitive and affective assessments of environmental protection objects [37]. Many previous studies confirm this claim and suggest that attitudes are important determinants of pro-environmental intentions [13,38]. Secondly, subjective norms capture an individual's perception of social pressure associated with a particular behavior [39]. Several studies indicate a positive relationship between subjective norms and intentions, suggesting that subjective norms may effectively predict environmental behavioral intentions [7,40]. It can be inferred that individuals are more likely to form pro-environmental intentions when they perceive that significant others support PEBs. Finally, PBC (including two dimensions—self-efficacy and controllability), is an important influence on behavioral intentions when some specific behaviors of people are partially controlled by volition [39]. Behavioral control and motivation determine behavior [41]. PBC allows individuals to effectively assess their ability to achieve desired behaviors [42]. It also considers people's grasp or control over external non-motivational factors (e.g., resources, opportunities, facilitators) [42]. People may have positive behavioral intentions if they perceive that they have the necessary resources and opportunities and that the behavior is controllable [43]. Furthermore, Ajzen argues that PBC can directly affect behavior beyond intention for two reasons [30]. First, even if intention remains constant, the effort required to complete a series of behaviors successfully may increase with PBC. Second, the more accurate the self-assessment, the more PBC can substitute for actual behavioral control, with behavioral control and motivation determining behavior [30,41]. Numerous studies demonstrate that PBC is positively correlated with PEB and pro-environmental intentions across various research contexts related to environmental behavior themes [37,44,45]. Based on Ajzen's TPB framework and empirical evidence, we propose the following hypotheses.

Hypothesis 2a (H2a). *Residents' attitudes are positively correlated with their pro-environmental intentions.*

Hypothesis 2b (H2b). *Residents' subjective norms are positively correlated with their pro-environmental intentions.*

Hypothesis 2c (H2c). *Residents' PBC is positively correlated with their pro-environmental intentions.*

Hypothesis 2d (H2d). *Residents' PBC is positively correlated with their PEBs.*

2.2. Environmental Policy of the Government

Environmental policy plays an indispensable role in environmental governance world-wide. A crucial aspect of environmental policy is the environmental policy tools, which encompass various methods and techniques employed by government agencies to exert their influence on society (e.g., values, beliefs, behaviors) to achieve environmental policy goals [46]. As the Chinese government's awareness of environmental issues increases, its environmental laws and policies are continually revised and improved [5], reflecting a firm and strong commitment to enhancing environmental quality. China's environmental policy system is comprehensive, comprising policies of the Communist Party of China, environmental laws, administrative regulations, environmental standards, local policies, international treaties, and other environmental policies aimed at improving the ecological environment [47].

To improve environmental performance more effectively, policies in the environmental sector increasingly focus on changing people's behavior [17,48]. Policymakers need to understand the relationship between policy measures and PEBs and the mechanistic pathways between them from a citizen's perspective to design and formulate more effective policies [49]. Later, scholars have continued to test and suggest that the extent to which people understand, perceive, and support environmental policies may impact their PEBs [50]. One study found that pro-environmental individuals may support environmental policies as an expression of their intrinsic pro-environmental motivations. Similarly, those who support environmental policies may engage in PEBs [51]. The study on car use suggests that when people live in countries that adopt solid environmental policies, they are likely to drive less in consideration of the environment, even if it is not specific to car use [52]. Steg and Vlek [53] argued that effective policy measures increase the attractiveness of PEBs. Fu et al. [16] contend that higher perceived policy effectiveness can help individuals translate awareness into PEB, narrowing the gap between awareness and behavior. Therefore, we propose the following hypothesis.

Hypothesis 3 (H3). *Residents' EPPs are positively correlated with their PEBs.*

People's reactions following the enactment or implementation of specific policies often indicate their subsequent intentions and actions. Firstly, as an external contextual factor, environmental policies, whether command-and-control, market-incentive, or voluntary, may influence individuals' internal factors such as cognitive, affective, or social aspects. Favorable contextual factors are expected to positively impact attitudes [54]. For instance, the introduction of recycling facilities may engender more positive attitudes towards recycling due to increased convenience [53]. Secondly, policies in institutional settings emanate from government agencies and exert institutional pressures that encourage the adoption of appropriate behaviors [55]. Through the talk, knowledge, and practice of environmental policies by those around them, individuals may experience the pressures and expectations of the institutional environment, potentially influencing their subjective norms. Thirdly, contextual factors may also influence people's perceptions of their level of control in performing particular behaviors [56]. When individuals perceive that the government provides strong support, the desired behavior may be viewed as more feasible [57]. For example, if environmental policies provide clearer guidelines for PEB, people may feel that they have greater control over their environmental behaviors' performance. A study by Jiang et al. [58] also found that residents read relatively high levels of content related to environmental policy knowledge in the messages disseminated by official government media. Therefore, we propose the following hypotheses.

Hypothesis 4a (H4a). *EPPs are positively correlated with residents' attitudes.*

Hypothesis 4b (H4b). *EPPs are positively correlated with residents' subjective norms.*

Hypothesis 4c (H4c). *EPPs are positively correlated with residents' PBCs.*

H4 indicates that EPP may positively influence attitudes, subjective norms, and PBC within the TPB framework. H1 and H2 indicate that the TPB framework variables have an impact on PEB. Hypothesis 3 indicates that there is a positive correlation between EPP and PEB. Therefore, we propose that EPP can influence PEB through the mediating pathways of TPB. Consequently, we formulate the following additional hypotheses.

Hypothesis 5a (H5a). *Residents' attitudes and pro-environmental intentions remotely mediate the relationship between EPPs and PEBs.*

Hypothesis 5b (H5b). *Residents' subjective norms and pro-environmental intentions remotely mediate the relationship between EPPs and PEBs.*

Hypothesis 5c (H5c). *Residents' PBC and pro-environmental intentions remotely mediate the relationship between EPPs and PEBs.*

Hypothesis 5d (H5d). *Residents' PBC mediates the relationship between EPPs and PEBs.*

2.3. The Mediating Role of SMU

The advancement of social media technology has not only facilitated easier access to information but also enabled people to share and interact with others, offering significant potential for promoting PEB [20,59,60]. Previous studies have indicated that the information people are exposed to may be transformed into personal perceptions, which subsequently guide behavior [61,62]. Social media, a new and important platform for the exchange and dissemination of news and information [63], boasts a large scale and frequent user participation [64]. Consequently, it presents an effective means of promoting PEB through the dissemination of environmental knowledge and information [5]. For instance, users' attention to climate change-related information on social media has been positively correlated with their PEBs [61,65]. It may be related to the fact that users can learn about and acquire environmental knowledge from the information [66]. Beyond the informational aspect, the functional design of social media platforms also contributes to promoting PEB. The information sharing, social networking, and interactive functions of social media provide multiple avenues for encouraging PEB [4]. For example, users can support various environmental protection activities by liking, sharing, and promoting online donation campaigns [4,23,62]. The viral spread of social media can persuade followers to share opinions and knowledge with their peers, shaping their PEBs [67,68]. Empirical studies support these observations. Zhang et al. [20] found that social applications can enhance users' value perception and willingness to participate in PEB, for example, using "Ant Forest", a popular social media application in China, which combines online games on environmental protection themes with offline low-carbon activities. Allison and Winkler [21] analyzed a Facebook group for fisheries conservation and found that Facebook's information, relationship, and experience functions can be used to promote members' environmental comments and practices. Therefore, we propose the following hypothesis.

Hypothesis 6 (H6). *SMU is positively correlated with residents' PEBs.*

Environmental communication research has demonstrated that an individual's attitude is influenced by how others perceive and react to media messages [69]. The "like" and "share" options on social media platforms are utilized to express users' explicit attitudes towards specific information [68,70], with real-time metrics displayed alongside media content. Social media communities persuade their followers to share opinions and knowledge with peers [67], and studies have found that media coverage of environmental issues positively affects individuals' environmental attitudes [71]. Awan et al. [72] verified the causal relationship between media use and pro-environmental attitudes and

behaviors using CGSS questionnaire data and instrumental variable methods, suggesting that environmental information knowledge serves as a mediating channel. Second, Hynes et al. [22] suggest that subjective norms include social norms and personal norms. It has been found that mass media can influence residents' social norms, which in turn affect residents' PEBs [73]. Social media can also effectively activate people's sense of interpersonal comparison, thereby enhancing their awareness of social and personal norms and promoting PEB [22]. Moreover, the viral indicators of "likes" and "shares" on social media also exert social normative pressure on people, especially on followers of green communities [23,70]. The interconnectedness of social media allows individuals to quickly learn about the behavior of others, which may in turn affect individual norms [74]. Finally, enhancing self-efficacy can strengthen the perceived degree of behavioral control [7,42]. Personal attention to information leads to their cognitive elaboration and learning from the media [65]. The social display and social recording functions of social media can provide learning opportunities and stimulate people's social comparison psychology, thereby enhancing self-efficacy [5]. Tong et al. [7] found that college students can use social media to learn about low-carbon knowledge and identify low-carbon behaviors that match their abilities, enhancing PBC and willingness to low-carbon behavior. Based on these findings, we propose the following hypotheses.

Hypothesis 7a (H7a). *SMU is positively correlated with residents' attitudes.*

Hypothesis 7b (H7b). *SMU is positively correlated with residents' subjective norms.*

Hypothesis 7c (H7c). *SMU is positively correlated with residents' PBC.*

Given our assumptions above about the positive effect of SMU on TPB-based environmental attitudes, subjective norms, and PBC, and the established relationship between TPB and PEB in H1 and H2, we posit that SMU will affect PEB through the mediating path of the TPB framework. Consequently, we propose the following additional hypotheses.

Hypothesis 8a (H8a). *Residents' attitudes and pro-environmental intentions remotely mediate the relationship between SMU and PEB.*

Hypothesis 8b (H8b). *Residents' subjective norms and pro-environmental intentions remotely mediate the relationship between SMU and PEB.*

Hypothesis 8c (H8c). *Residents' PBCs and pro-environmental intentions remotely mediate the relationship between SMU and PEB.*

Hypothesis 8d (H8d). *Residents' PBCs mediate the relationship between SMU and PEB.*

The antecedents of SMU are infrequently discussed in the literature. Brailovskaia et al. [75] argue that information acquisition and socialization are the main reasons people use social media. Social media has emerged as a major source of information [76], and environmental policy may initially be perceived through channels such as traditional media and incidental news exposure on social media platforms [77]. According to the cognitive mediation model theory, individuals first actively attend to news, then process and cognitively elaborate on the information to acquire knowledge [78,79]. Users can embed the elaboration of environmental policy information into social media content [80] and persuade their followers to share views and knowledge with others [67] (Figure 1a). Subsequently, other users can browse social media to obtain additional information and learn from it [23]. Second, Government agencies are increasingly registering official social media accounts to promote environmental policies, with their information considered more authoritative and credible [12,14,81,82] (Figure 1b). Beyond information dissemination, these agencies utilize official social media accounts to communicate online with the public. It is found that the

conversation cycle and different content topic strategies used on government social media can significantly affect public participation and improve public understanding and support for government policies [12,14].
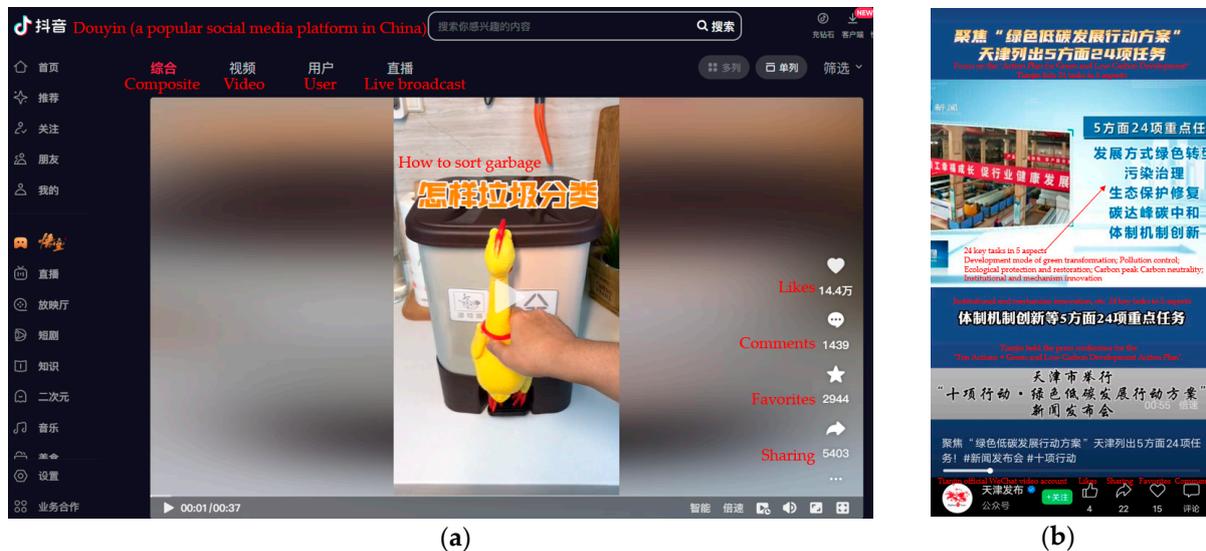

(**a**)　　　　　　　　　　　　　　　(**b**)

Figure 1. Examples of environmental policy content on social media. (**a**) A user's elaboration of environmental policy information on social media (Douyin), and the social content has been spread virally; (**b**) the local government authorities register official accounts on social media (WeChat) and publicize the environmental policy. The red letters are the translation of the chinese content.

In addition, the unique interactive features of social media also influence public perception and evaluation of information, subsequently affecting users' willingness to engage with and discuss content on these platforms. When environmental policy information receives a high number of "likes" and "shares" and spreads virally, it can encourage people to follow the crowd [23,68,70,83] (Figure 1a). The emotional price embedded in environmental policy information will further stimulate individuals' desire to share emotions and participate in social media [12,84]. In summary, after individuals perceive environmental policies, they may use social media to engage in cognitive learning, interact with official media, and participate in viral spread. Therefore, we propose the following hypothesis.

Hypothesis 9 (H9). *Residents' EPPs are positively correlated with SMU.*

According to H9, when people perceive environmental policy, they may use social media in ways such as elaborative learning, interacting with the authorities, and joining viral transmission. H6, H7, and H8 have already discussed the relationship between SMU and PEB. Therefore, we propose the following hypotheses.

Hypothesis 10 (H10). *SMU mediates the relationship between EPP and PEB.*

Hypothesis 11a (H11a). *SMU, attitude, and pro-environmental intention remotely mediate the relationship between EPP and PEB.*

Hypothesis 11b (H11b). *SMU, subjective norm, and pro-environmental intention remotely mediate the relationship between EPP and PEB.*

Hypothesis 11c (H11c). *SMU, PBC, and pro-environmental intention remotely mediate the relationship between EPP and PEB.*

Hypothesis 11d (H11d). *SMU and PBC remotely mediate the relationship between EPP and PEB.*

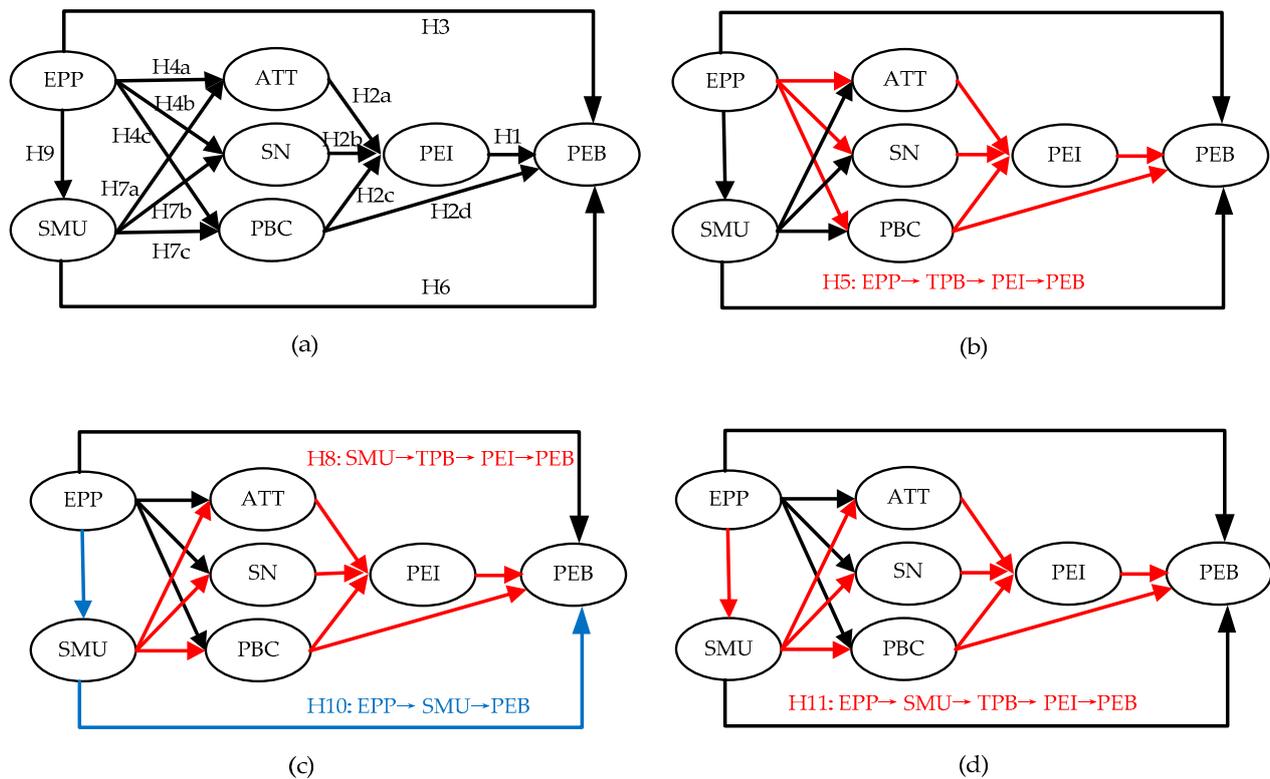The proposed theoretical framework is shown in Figure 2.

Figure 2. The proposed theoretical framework. (**a**) hypotheses of direct paths (black arrows); (**b**) hypothesis of indirect path: EPP→TPB→PEI→PEB (red arrows); (**c**) hypotheses of indirect paths: SMU→TPB→PEI→PEB (red arrows), EPP→SMU→PEB (blue arrows); (**d**) hypothesis of indirect path: EPP→SMU→TPB→PEI→PEB (red arrows). Note: EPP—environmental policy perception. ATT—attitude. SN—subjective norm. PBC—perceived behavior control. PEI—pro-environmental intention. PEB—pro-environmental behavior. SMU—social media use. TPB—including ATT, SN, and PBC within the framework of TPB.

3. Data and Methods

3.1. Measurement

We measured the variables using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The questionnaire was designed by referencing well-established scales widely cited in the literature, with consideration given to the expression of measurement items to ensure applicability to Chinese respondents. All constructs, item contents, standard factor loadings, and Cronbach's alpha values are reported in the Supplementary Material Table S1.

Environmental policy perception. The measurement of environmental policy perception is mainly extracted from the scales developed by Wan et al. [50]. Our items measure environmental policies in terms of people's self-assessed knowledge of policies and the perceived effectiveness of policies. The scale consists of five items, including statements such as "I think the government can provide clear guidelines on PEB".

Attitude, subjective norm, and perceived behavioral control. The measures of attitude, subjective norm, and PBC are referenced from an earlier scale by Ajzen [30]. Also, to fit the environmental context, our scale is adapted from Yadav and Pathak's scale [38].

Pro-environmental intention. Many scholars measure pro-environmental intentions based on Azjen's scale of behavioral intentions [30]. We refer to Ateş's scale to measure pro-environmental intentions [35].

Pro-environmental behavior. The measure of PEB is extracted from the resident questionnaire of the Chinese General Social Survey (CGSS, http://cgss.ruc.edu.cn/, accessed on 20 January 2022). CGSS is the earliest national, comprehensive, and continuous academic survey project in China, sponsored by the Renmin University of China. The CGSS questionnaire is considered one of the most important data sources for studying social issues in China [85]. For example, the measurement and data on PEB in the studies of Awan et al. [72] and Gong et al. [85] were all derived from the CGSS questionnaire. Therefore, we extracted four common items to measure PEB, such as "I will bring a shopping basket or bag when purchasing daily necessities". *Social media use.* The questions measuring social media use are adapted from the resident questionnaire of CGSS and the study of Leftheriotis et al. [86]. We developed three questions to assess residents' use of social media platforms (e.g., WeChat, Weibo, QQ, Douyin, Kuaishou) for interactions with government, institutions, and social organizations.

3.2. Data Collection and Samples

We selected Tianjin, China, one of the country's four major municipalities, as our study area. On the official website of "The Tianjin Ecology and Environment Bureau" (http://sthj.tj.gov.cn/, accessed on 20 January 2022), we could retrieve the relevant policy documents on ecological and environmental governance in Tianjin. For example, on 17 January 2022, the Tianjin Municipal People's Government issued the "14th Five-Year Plan for Ecological Environmental Protection in Tianjin", emphasizing the creation of a better productive and living environment for the people. In our paper, considering that the research object of this study is the pro-environmental behavior of Tianjin residents, the "environmental policies" mainly refer to the policies that are closely related to residents in Tianjin, such as the existing policies on waste classification, green community, and heavy pollution air treatment. Moreover, we provided a brief description of the definition and scope of environmental policy in the questionnaire.

Data for this study were collected through a questionnaire survey administered to Tianjin residents. We prepared both electronic (Using the "wenjuanxing" platform, https://www.wjx.cn/, accessed on 20 January 2022) and paper versions of the questionnaire, allowing respondents to participate freely and voluntarily. Before filling out the questionnaire, we promised anonymity and confidentiality of the information. Small gifts or small monetary rewards were used as incentives to encourage respondents to fill out the questionnaire. We distributed and returned 452 questionnaires, excluding 44 invalid questionnaires, and obtained 408 valid questionnaires (81 electronic questionnaires and 327 paper questionnaires). The sample was collected in two ways, so the issue of sampling bias needed to be considered. Referring to Fleming and Bowden [87], the results of the chi-square test and the columnar analysis showed that no overall significant differences in the demographic variables' distribution or the critical variables' structure were found between the electronic and paper questionnaire samples. The issue of sampling bias was not significant. Descriptive statistics of the sample are shown in the Supplementary Materials, Table S2.

3.3. Common Method Bias Test

The common method bias (CMB) test was calculated using Harman's single factor [88]. According to relevant reference recommendations, the CMB problem is considered severe when the single factor exceeds 50% variance [89]. Our test results indicated that the first principal component accounted for 35.169% of the variance, implying that the first factor was far from explaining most of the variance. Therefore, CMB was unlikely to be a major problem in our study.

4. Data Analysis and Results

We used IBM SPSS Statistics 25 and Mplus 7.4 software to analyze the data, including two steps—confirmatory factor analysis (CFA) and SEM—to evaluate the proposed research

model and verify the theoretical hypothesized relationships between the variables. The maximum likelihood method (ML) was used to estimate the measurement and structural models [90].

4.1. Measurement Model Analysis

We used CFA to test the reliability, convergent validity, and discriminant validity of the measurement model, and the results are shown in Table 1.

Table 1. Reliability, convergent validity, and discriminant validity results.

DIM	Composite Reliability	Convergence Validity	Discriminant Validity						
	CR	**AVE**	**EPP**	**SMU**	**ATT**	**SN**	**PBC**	**PEI**	**PEB**
EPP	0.844	0.523	**0.723**						
SMU	0.842	0.640	0.390 ***	**0.800**					
ATT	0.842	0.646	0.383 ***	0.307 ***	**0.804**				
SN	0.888	0.727	0.400 ***	0.287 ***	0.478 ***	**0.853**			
PBC	0.762	0.518	0.341 ***	0.254 ***	0.531 ***	0.582 ***	**0.720**		
PEI	0.920	0.793	0.228 ***	0.300 ***	0.401 ***	0.428 ***	0.558 ***	**0.891**	
PEB	0.786	0.489	0.417 ***	0.386 ***	0.319 ***	0.479 ***	0.469 ***	0.544 ***	**0.699**

Note. *** $p < 0.01$. The right side of the table except the diagonal shows the Pearson correlation matrix. Square root of AVE for each construct is shown in the diagonal of the correlation matrix and was bolded. EPP—environmental policy perception. SMU—social media use. ATT—attitude. SN—subjective norm. PBC—perceived behavior control. PEI—pro-environmental intention. PEB—pro-environmental behavior.

Cronbach's alpha values were predominantly above 0.7 (Table S1), and component reliability (CR) values also exceeded 0.7, indicating that the questionnaire measures demonstrated satisfactory internal consistency reliability. The majority of items exhibited standardized factor loadings greater than 0.6, with only a few falling between 0.5 and 0.6, which remained within acceptable limits. The average variance extracted (AVE) values were above 0.45, suggesting overall good convergence of the measured variables [91]. The square root of all AVE values was greater than the Pearson correlation coefficient between the latent variables, indicating good discriminant validity of the measured variables [92]. These analyses collectively indicated that our measurement model demonstrated good reliability, convergent validity, and discriminant validity.

4.2. Alternative Model Test

To test the reliability of the constructed models, we compared the fit indices of the primary model (Model 4) with the three alternative models. Model 1 was a fundamental relationship model of EPP with PEB based on TPB theory. In Model 2, we added the direct relationship between EPP and PEB. Model 3 was added to Model 2 with the SMU variable. Model 4 was added to Model 3 with the relationship between SMU and TPB. The relationships of the variables from Model 1 to Model 4 are shown in Figure 3.

Table 2 shows the results of the indices of fit for the four models. According to the recommendations of Anderson and Gerbing [90], the constructed model was well fitted to the data if $1 < \chi^2/\text{df} < 3$, RMSEA < 0.08, CFI > 0.9, TLI > 0.9, and SRMR < 0.08. Compared with base Model 1, Model 2 suggested that EPP had a relationship with PEB other than the TPB framework. Therefore, with the addition of the SMU variable, all the fit indices of Model 3 were improved over Model 2. After further building the relationship between SMU and TPB, Model 4 generally had better-fit results than Model 3. The above test results indicated that our primary model was relatively reliable.
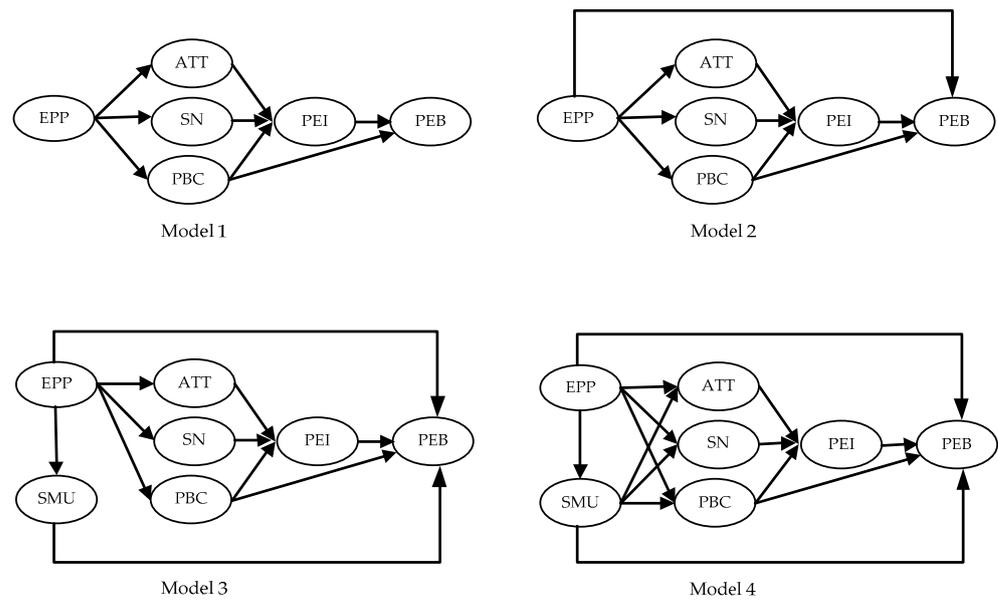
Figure 3. Comparison of the alternative models (Models 1–3) and the primary model (Model 4).

Table 2. Comparison of explanatory degree and goodness of fit of alternative models.

Models	Adj. R^2	χ^2	df	χ^2/df	RMSEA	CFI	TLI	SRMR
Model 1	0.454	618.455	181	3.417	0.077	0.906	0.891	0.117
Model 2	0.518	585.621	180	3.253	0.074	0.913	0.898	0.110
Model 3	0.530	676.398	241	2.807	0.067	0.917	0.905	0.099
Model 4	0.535	657.865	238	2.764	0.066	0.920	0.908	0.096

Note. Adj. R^2—the degree of explanation of PEB. χ^2—chi-square test of model fit. df—degrees of freedom. RMSEA—root mean square error of approximation. CFI—comparative fit index. TLI—Tucker–Lewis index. SRMR—standardized root mean square residual.

4.3. Structural Model and Hypothesis Testing

4.3.1. Result of Direct Paths

The SEM technique provided by the Mplus 7.4 software allowed us to test structural models that included mediating variables. As suggested by Iacobucci et al. [93], the SEM method was more suitable for our study than Baron and Kenny's method [94]. After testing the measurement model and alternative models, we evaluated and analyzed the structural model and relational paths. The standardized path coefficients for the structural model are shown in Figure 4.
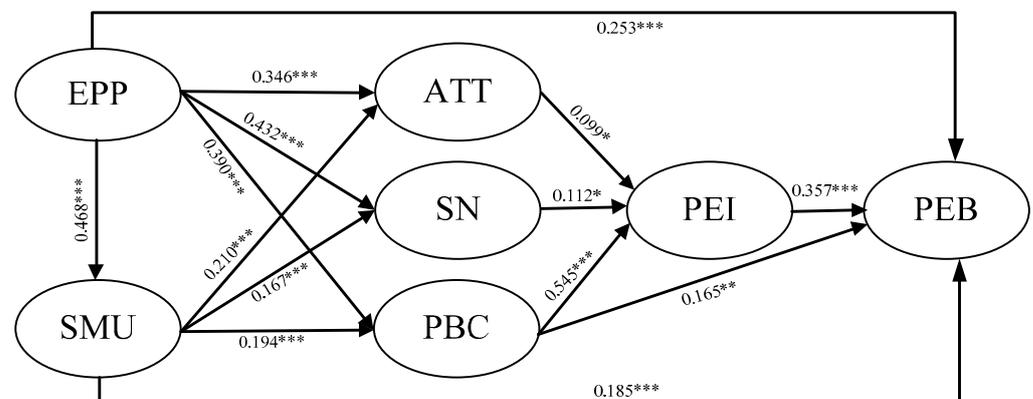

Figure 4. Path coefficients for the final structural model. Note. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Solid arrows indicate the significant paths.

As shown in Figure 4, all hypotheses of direct relationships were tested. According to the TPB theoretical framework, PEI (β = 0.357, p < 0.01) was positively related to PEB, with H1 being supported. Attitude (β = 0.099, p < 0.1), subjective norm (β = 0.112, p < 0.1), and PBC (β = 0.545, p < 0.01) were positively related to PEI. PBC (β = 0.165, p < 0.05) was positively related to PEB. H2 was supported. Secondly, EPP (β = 0.253, p < 0.01) positively influenced PEB, and H3 was supported. EPP positively influenced attitude (β = 0.346, p < 0.01), subjective norm (β = 0.432, p < 0.01), and PBC (β = 0.390, p < 0.01), with H4 being supported. SUM also positively related to attitude (β = 0.210, p < 0.01), subjective norm (β = 0.167, p < 0.01), and PBC (β = 0.194, p < 0.01), with H7 being supported. Finally, SUM (β = 0.185, p < 0.01) positively affected PEB and was also positively affected by EPP (β = 0.468, p < 0.01), with both H6 and H9 being supported.

4.3.2. Result of Indirect Paths

To further analyze the mediation effects, we used the bootstrap approach for testing. For testing mediating effects, the bootstrap approach is considered more reliable and can produce more accurate results than normal theoretical tests such as the Sobel test [95]. We examined mediation effects based on a sample of 5000 bias-corrected bootstrap programs with 90% confidence intervals (CI, CI values are significant when not containing 0). The results of the mediated effects test are shown in Table 3. First, attitude and PEI remotely mediated the relationship between EPP and PEB, and H5a was supported. The coefficient of EPP (E = 0.016, CI = [0.000, 0.044]) based on the distal mediating path of subjective norm and PEI was not significant, with H5b not being supported. PBC and PEI remotely mediated the relationship between EPP and PEB, and H5c was supported. Furthermore, EPP also affected PEI via PBC only, and H5d was supported. Secondly, Similar to H5, the remote mediating path coefficients for attitude and PBC were significant except for the subjective norm. H8a, H8c, and H8d were supported, H8b was not. Thirdly, EPP (E = 0.079, CI = [0.035, 0.139]) affected PEB via the path of SMU, with H10 being supported. Finally, regarding the test of the distal mediation effect of EPP via SMU and TPB, only the remote paths via PBC were significant. H11c and H11d were supported.

Table 3. Results of indirect effects test based on the bias-corrected bootstrapping method.

Indirect Paths	E	SE	Bias-Corrected 90% CI		Hypothesis
			Lower Limit	Upper Limit	
EPP→ATT→PEI→PEB	0.011	0.008	0.002	0.030	H5a supported
EPP→SN→PEI→PEB	0.016	0.014	0.000	0.044	H5b not supported
EPP→PBC→PEI→PEB	0.070	0.028	0.035	0.133	H5c supported
EPP→PBC→PEB	0.059	0.041	0.005	0.138	H5d supported
SMU→ATT→PEI→PEB	0.005	0.005	0.001	0.017	H8a supported
SMU→SN→PEI→PEB	0.005	0.005	0.000	0.021	H8b not supported
SMU→PBC→PEI→PEB	0.026	0.017	0.005	0.063	H8c supported
SMU→PBC→PEB	0.022	0.020	0.001	0.071	H8d supported
EPP→SMU→PEB	0.079	0.031	0.035	0.139	H10 supported
EPP→SMU→ATT→PEI→PEB	0.003	0.003	0.000	0.011	H11a not upported
EPP→SMU→SN→PEI→PEB	0.003	0.003	0.000	0.013	H11b not upported
EPP→SMU→PBC→PEI→PEB	0.016	0.011	0.005	0.042	H11c supported
EPP→SMU→PBC→PEB	0.014	0.013	0.001	0.045	H11d supported

Note. N = 408. B—non-standardized path coefficient. CI—confidence interval. CIs are based on the bias-corrected bootstrapping of 5000 samples.

4.3.3. Result of the Moderating Role of Demographic Factors

Apart from direct and indirect effects, we also examined the moderating role of demographic factors regarding EPP and SMU. In Table 4, Panels A and B, respectively, represent the moderating roles of gender and age. Panel A indicates that the moderating role of gender on relationships between EPP and PEB was not significant (difference = −0.129, p > 0.1). Except for PBC, gender could negatively moderate the effect of EPP on SMU,

attitudes, and subjective norms. This means that females were less sensitive to EPP than males. Additionally, females used social media more than males to promote their PEB (difference = 0.139, $p < 0.1$). Panel B indicates that age did not significantly moderate the effect of EPP on PEB and SMU. However, age could positively moderate the effect of EPP on attitude, subjective norm, and PBC. In addition, the moderating role of age on the relationship between SMU and PEB was significant (difference = 0.130, $p < 0.1$).

Table 4. Result of the moderating roles of sex and age.

Panel A	Path Coefficients				Results
The Paths	Male	Female	Difference	*p*-Value	
EPP→PEB	0.318 ***	0.189 ***	−0.129	0.286	male = female
EPP→SMU	0.790 ***	0.504 ***	−0.287 *	0.055	male > female
SMU→PEB	0.039	0.178 ***	0.139 *	0.089	male < female
EPP→ATT	0.475 ***	0.241 ***	−0.234 *	0.061	male > female
EPP→SN	0.795 ***	0.410 ***	−0.385 **	0.021	male > female
EPP→PBC	0.378 ***	0.345 ***	−0.033	0.791	male = female
Panel B	**Path Coefficients**				**Results**
The Paths	Youth	Elderly	Difference	*p*-Value	
EPP→PEB	0.220 ***	0.224 *	0.005	0.971	youth = elderly
EPP→SMU	0.539 ***	0.741 ***	0.202	0.201	youth = elderly
SMU→PEB	0.076	0.205 ***	0.130 *	0.088	youth < elderly
EPP→ATT	0.162 **	0.675 ***	0.512 ***	0.000	youth < elderly
EPP→SN	0.315 ***	0.945 ***	0.630 ***	0.000	youth < elderly
EPP→PBC	0.219 ***	0.491 ***	0.272 **	0.027	youth < elderly

Note. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Youth ≤ 35 years old. Elderly > 35 years old. Referring to China's "Mid-and Long-Term Youth Development Plan (2016–2025)", the two age groups ≤35 are set to 0, representing the youth; the three age groups >35 are set to 1, representing the elderly.

5. Discussion

Our results demonstrate a positive correlation between EPP and PEB, aligning with previous studies on EPP in the Chinese context [16,17,50]. However, this study's more significant contribution lies in addressing Okumah et al.'s call for elucidating the mechanism and evidence of environmental policy factors' influence on PEB [18]. Unlike previous studies, it provides both a theoretical explanation and empirical evidence based on the systematic theory of planned behavior framework for the mechanism by which EPP affects PEB. Notably, our model achieves an explanation degree of 0.535 for PEB. Compared with the previous model between EPP and PEB constructed by Wang and Mangmeechai ($R^2 = 0.42$) [17], the model based on the theory of planned behavior between media use and PEB constructed by Karimi et al. ($R^2 = 0.45$) [96], our comprehensive model has a better explanatory power for PEB.

Our findings reveal that attitudes and perceived behavioral control mediate the effect of EPP on PEB. Lichtenthaler and Ernst [97] argue that external (positive) knowledge and experience can alter individual attitudes. Li et al. [98] suggest that environmental policies can shape individuals' self-perception mechanisms and promote self-persuasion, which in turn can lead to supportive attitudes. Even if environmental policies may increase the cost of living and reduce convenience [99], individuals will rebuild their attitudes towards environmental policies to mitigate cognitive dissonance because they are afraid of being punished and unable to behave differently [98]. When individuals positively evaluate the consequences of PEB, they are more willing to engage in the behavior. Furthermore, Nasri and Charfeddine [57] suggest that individuals may view desired behaviors as more feasible when they perceive strong governmental support. In our context, municipal environmental policies enhance individuals' self-efficacy by providing operational guidelines for PEB. As Yin et al. [100] find, individuals' perceived behavioral control is enhanced when they perceive that waste sorting policies are effective, such as the availability of convenient trash

cans and instructions. Once individuals believe that recycling is easy, the possibility of recycling behavior will increase. The non-significance of the subjective norm mediating path aligns with Singh et al. [101]'s findings on transfer learning intentions, where intentions are primarily influenced by attitudes and perceived behavioral control, with negligible effects from subjective norms. Chan [73] argues that personal views are more crucial in determining behavioral intentions than external social pressures from government, media, and other sources. Hynes et al. [22] offer a more systematic explanation, arguing that subjective norms comprise both social and personal norms with varying relative importance. People tend to judge others' adherence to social norms through comparison but do not apply these judgments to personal norms, as they are guided by their own perceived obligation to follow norms.

Another significant contribution of this paper is expanding the theory of planned behavior framework by incorporating SMU to elucidate the mechanism linking EPP and PEB. While previous studies have established a positive relationship between SMU and PEB [20,21,23], the underlying mechanisms remain largely unexplored. Recently, Tong et al. [7] have attempted to explain the impact mechanism of SMU on PEB using the TPB framework, finding that subjective norms and perceived behavioral control mediate the effect of SMU on low-carbon behavior but not attitudes. Our findings diverge from Tong et al.'s results, indicating that SMU positively influences PEB through the mediating paths of attitude and perceived behavioral control. This discrepancy may be attributed to differences in sample characteristics. Tong et al.'s study focuses on college students with similar education and age, subject to external normative pressures from the college environment. In contrast, our sample is more diverse, encompassing various age groups and education levels, thus complementing and extending Tong et al.'s findings on the SMU-PEB relationship. Awan et al. [72] argue that attitudes can mediate the relationship between traditional media and PEB. Our study complements Awan et al.'s work by finding that attitudes can also mediate the relationship between SMU and PEB. Social media communities can persuade their followers and peers to share environmental-related views and knowledge, and the viral spread characteristics of social media platforms can also affect the shaping of users' environmental attitudes. Perceived behavioral control also mediates the relationship between SMU and PEB, consistent with previous studies [73,96]. However, compared with previous studies that use traditional media or full-form media as independent variables [73,96], we highlight the findings in the context of social media. Individuals not only cognitively process environmental information from social media, but also utilize the learning opportunities provided by the social display and social recording functions of social media to enhance their sense of self-efficacy. In the relationship between SMU and PEB, the mediating path of subjective norms remains insignificant. As mentioned above, the individual norm plays a more important role than the social norm in the two components of the subjective norm, while the SMU can only influence the social norm [22].

Crucially, we demonstrate that EPP positively affects SMU, contributing to the literature on SMU antecedents and broadening the scope of discussion on the SMU-PEB relationship. After perceiving environmental policies, individuals may engage with social media through searching and elaborating policy information [79,80], interacting with officials [12,14], and participating in viral transmission [23,67,68]. Our results also reveal that EPP remotely mediates the relationship with PEB through the paths of SMU and perceived behavioral control. However, the mediating path of attitude is unstable. Analysis of our sample data suggests gender differences in the effect of EPP on attitude, while no such difference is observed in the effect of EPP on perceived behavioral control. And Huang et al. [102] use internet-derived data and identify heterogeneity in public attitudes on social media regarding EPP for waste sorting. In the framework of planned behavior theory, perceived behavioral control is generally regarded as the strongest factor influencing PEB [96], and our results also prove to be the most stable. When individuals perceive environmental policies, they actively use social media to search, learn, interact, and spread information.

This process can also enhance self-efficacy and confidence in behavior control, ultimately promoting PEB.

In addition, we examine the moderating role of demographic factors on EPP, responding to a recent call by Wang and Mangmeechai [17] and contributing to the current understanding. Our findings reveal significant gender and age differences in the impact of EPP on various constructs within our model. Compared with females, males demonstrate greater sensitivity to EPP, positively moderating the relationship between EPP and attitude, subjective norm, and SMU. This heightened sensitivity may be attributed to males generally having a more significant interest in politics and paying more active attention to government policy information [103]. Additionally, males' higher propensity for social media addiction [104] may increase their exposure to incidental environmental policy news. Conversely, females exhibit a stronger relationship between SMU and PEB than males. This finding aligns with previous research suggesting that females possess more altruistic tendencies, making their environmental attitudes more susceptible to influence through social media use, which in turn affects PEB [7,105]. Regarding age, our results reveal that age has a positive but insignificant effect on the relationship between EPP and SMU. However, age positively and significantly moderates the relationship between EPP and attitude, subjective norm, and perceived behavioral control. This means that the elderly are more sensitive to environmental policies than the young, so that EPP has a greater impact on attitudes, subjective norms, and perceived behavioral control. The study by Alzahrani et al. [106] finds that older people trust e-government more than younger people. Consequently, older individuals may be more inclined to trust environmental policy information from both traditional and social media sources. Additionally, age can also positively moderate the relationship between SMU and PEB. The elderly may be more likely to engage in environmentally friendly behaviors [107], so they will be more active in using social media to obtain environmental information and share it with others to promote PEB practices.

Finally, understanding the mechanisms by which EPP influences PEB can assist policymakers in enhancing the efficacy of environmental policy design and implementation [49]. First, EPP can affect PEB through attitudes and perceived behavioral control pathways. Crafting precise and informative content can yield greater persuasive effects. Rather than relying on environmental preaching, governmental explanations and promotions of environmental policies should focus more on knowledge dissemination and incentive structures. In policy implementation, it is crucial to strengthen the link between policy objectives and individual responsibility. For instance, establishing individual green accounts, which record individuals' PEBs and allow them to redeem rewards by accumulating behavioral points, could incentivize residents to internalize social normative pressures into personal norms. Secondly, the dissemination of environmental policies should not overlook social media, a prevalent information transmission platform. Municipal authorities can utilize official accounts to publicize environmental policies and increase incidental exposure to environmental policy news. They can also leverage social media's interactive features to enhance users' comprehension of and support for environmental policies by initiating diverse topics, addressing inquiries, and elucidating policy guidelines. Collaboration with social media influencers to produce content about environmental policies can harness viral dissemination to shape public perception and willingness to implement. In addition, municipalities can take advantage of the demographic factors to enhance the effect of EPP. For example, they can set up incentives to encourage males and the elderly to participate in the secondary dissemination of environmental policy information, thereby expanding the scope of policy impact.

6. Conclusions

Using SEM and survey data from 408 residents in Tianjin, China, we examine the mechanistic relationships between EPP and PEB within an extended framework of TPB. The results indicate that EPP can positively affect PEB and remotely mediate the relationship

through the paths of attitude and perceived behavioral control. Furthermore, we expand the explanatory power of the TPB framework by incorporating the SMU variable. Results indicate a positive correlation between EPP and SMU, with SMU mediating the relationship between EPP and PEB. Additionally, SMU and perceived behavioral control jointly serve as remote mediators in the EPP-PEB relationship. Lastly, we investigate the moderating effects of gender and age on EPP. Our results reveal that males exhibit greater sensitivity to EPP compared with females and positively moderate the relationships between EPP and SMU, as along with attitude and perceived behavioral control. Age not only positively moderates the relationships between EPP and attitude, subjective norms, and perceived behavioral control, but also the relationship between SMU and PEB. This study, for the first time, analyzes the composite mediating effect of TPB variables and SMU, as along with the moderating effect of demographic factors, to explore the mechanism of EPP on PEB, thus expanding the boundaries of research on the antecedents of PEB. Policymakers can optimize policy design and implementation choices to promote PEB and environmental sustainability by leveraging the mediating channels of attitudes, perceived behavioral control, and SMU, and the amplifying effects of gender and age.

Some limitations of our study should be acknowledged. Firstly, the main variables are derived from self-reported questionnaire data, which are inherently subjective and may deviate from objective facts and behaviors observed in reality. Second, our investigation is confined to Tianjin, China, without a comparative analysis of residents in diverse regions. Future research could extend the scope to a broader range of cities, countries, or regions to examine the stability and heterogeneity of the mechanism between EPP and PEB. Thirdly, our study exclusively explores the relationship between EPP, SMU, and PEB within the TPB framework, achieving an explanatory power of 0.535 for PEB. However, mechanism analyses based on alternative theoretical models, such as NAM and VBN, or the integration of various theoretical models is worth discussing and comparing.

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