

Original Research

The Impact of Penalty on Residents' Waste Separation Behavior: A Moderated Mediation Model

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Abstract

To alleviate the plight of municipal solid waste management, penalties were implemented in China. However, it is unclear how penalty affects residents' waste separation behavior. This study aims to analyze the impact of penalty on residents' waste separation behavior and the role of personal norms and trust in authorities. A theoretical model of the impact of penalty on residents' waste separation behavior was established based on deterrence theory and normative activation model. Using online survey data from 628 respondents in Zhengzhou, China, an empirical analysis was performed by employing the moderated mediation model. The results showed that residents' perceived penalty certainty and penalty severity positively influenced their waste separation behavior through the mediation effect of personal norm. Penalty certainty had a direct impact on waste separation behavior, whereas penalty severity had no direct impact on waste separation behavior. Trust in authorities positively moderated the mediation effect of personal norm. The higher the trust in authorities, the stronger mediating effect of personal norm. Some recommendations were proposed to improve residents' waste separation behavior under the mandatory policy. This paper presents a new perspective and theoretical guidelines for the local government to improve residents' waste separation behaviors in China and offers useful insights into waste separation management for other countries.

Keywords: penalty certainty, penalty severity, personal norm, trust in authorities, waste separation behavior

Introduction

Improper municipal solid waste management is detrimental to human health and causes serious pollution to the soil, air, and ocean [1]. In recent years,

the world has been struggling with the rapid growth of municipal solid waste, and the global annual generation of municipal solid waste will climb to 3.4 billion metric tons by 2050 [2]. How to dispose of the growing amount of solid waste is an essential topic regarding sustainable waste management, and has become a great challenge for countries around the world [3, 4].

As a recognized means to reduce waste generation and improve recycling, waste separation

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was highly valued by countries around the world. Local governments in the United States implement curbside pricing programs and offer recycling services to households [5]. Japan has made remarkable achievements in waste separation, recovering a variety of resources from solid waste each year [6]. The Chinese government has made tremendous efforts in waste separation to solve the dilemma of the “garbage siege” [7]. Nevertheless, early interventions in China were dominated by voluntary policies, resulting in low public participation and poor achievements in waste separation [8]. Given this, the mandatory waste separation policy was proposed by the Chinese government in 2017. In the pilot cities of mandatory policy, penalties for illegal disposal of domestic wastes were stipulated. For example, Zhengzhou citizens are required to put their waste into specific garbage bins at scheduled times. Residents who improperly dispose of waste would be fined 50 yuan (about US\$ 7.465). However, it has been shown that economic measures (such as rewards and penalties) can crowd out people’s intrinsic moral responsibility for pro-environmental behavior because the public will believe that pro-environmental behavior is necessary only when there are rewards [7]. And even, the penalty measures may invite people’s dissatisfaction with waste separation [9]. Therefore, the effectiveness of penalties in guiding residents to participate in waste separation needs to be further studied.

China, as the world’s largest developing country, can offer worthwhile experiences for other developing countries to learn from in the practice of waste separation management. However, there are still some unanswered questions. For example, how penalty affects the participation of residents in waste separation in China? What is the relationship between penalty, personal norms and waste separation behavior (WSB)? Is the above relationship moderated by trust in the authorities? The answers to these questions have practical implications for the governments of the mandatory policy pilot cities to effectively guide residents to separate waste, and provide a valuable reference for other cities and countries to formulate waste separation policies. Therefore, it is crucial and necessary to study the impact of penalty on residents’ WSB in China.

This study investigated the impact of penalty on WSB from the perspectives of penalty certainty and penalty severity, and explored the role of personal norms and trust in authorities. The main contributions of this study are emphasized below. First, a new theoretical framework that explains the impact of penalty on residents’ WSB was constructed by combining deterrence theory and norm activation model. The paper extends deterrence theory and norm activation model. Second, the moderating effect of trust in authorities between penalty and WSB was confirmed, which enriches the research on WSB and emphasizes the importance of trust in authority. Third, punishing

for improper WSB is a new policy measure that has not been fully studied and widely adopted. The findings of this study provide a theoretical reference for waste separation policy makers. There are certain scientific values in this paper. On the one hand, it provides a theoretical framework for the academic community, which can be used to investigate the effects of penalty on other pro-environmental behaviors. On the other hand, this study offers a practical reference for local governments in guiding residents to sort their waste under the mandatory policy.

Literature Review

Many scholars have focused on the treatment and disposal of solid waste. For example, Shkileva [10] analyzed the implementation of degassing systems in municipal solid waste landfills, and found that landfill gas is an important element in the adverse environmental impact of waste landfills. Several studies have investigated the technical issues involved in waste separation. For instance, Narayanswamy et al. [11] explored the optimal multiclass waste classification methods, and compared three image algorithms for waste classification. Fadlil et al. [12] studied two methods, namely Convolutional Neural Network and Support Vector Machine, by comparing the training process and the accuracy results of the classification. They found that Convolutional Neural Network is more accurate than Support Vector Machine.

The success of waste separation requires not only technical support, but also the participation of the public. Hence, many studies have emerged on residents’ WSB and its influencing factors, which cover three aspects, namely individual motivational, social, and facility factors. First, many studies explored the influence of individual motivational factors on residents’ WSB based on the theory of planned behavior and normative activation model [13-15]. The results showed that individual motivational factors, such as attitude toward waste separation, environmental concern, institutional trust, and awareness of consequences, positively affected residents’ WSB [16-18]. However, a few scholars held a different view. For example, Shi et al. [19] found that residents’ willingness to waste sorting was not related to awareness of consequences. Second, social factors refer to the social environment that people face when making behavioral decisions about waste separation, including social norm, neighbor networks, community leadership, etc. [20-23]. Most previous studies indicated that social factors positively influenced residents’ WSB [21]. Third, facility factors are generally related to the convenience of performing waste separation, such as infrastructure, distance to the recycling station, and temporary space for waste. Most studies showed that facility factors positively affected residents’ WSB [24-26]. For example, Ma et al. [27] found that infrastructure had an indirect

influence on residents' WSB through the mediating role of perceived cost.

Penalty, as one of the policy tools to motivate the public to participate in waste separation, has also raised concerns of scholars. Many studies held a positive attitude toward penalties for improper WSB [28]. For instance, Zheng et al. [29] conducted the evolution simulation of WSB in social networks using 259 online questionnaires data, and proposed that penalty policy should be encouraged to guide residents to separate waste. Hao et al. [7] found that the existence of penalty positively influenced WSBs of college students in Zhengzhou, China. However, some studies reported that penalties have limitations. Ogiri et al. [30] studied whether sanctions could motivate Malaysian residents to participate in household waste recycling using the structural equation model (SEM), and found that only 25% of compliance behavior was interpreted by certainty and severity of sanction. Yang et al. [9] argued that penalty may reinforce the negative mindset that pro-environmental behavior is considered valuable only when individual interests are involved. They also found that penalty exerted a negative spillover effect on residents' acceptability of price increasing policy. Thus, whether the penalty should be implemented from the mandatory waste separation pilot cities to a nationwide scale in China remains to be further studied.

Although numerous studies have been conducted on residents' WSB, there are still shortcomings in the existing studies. First, much attention has been focused on the factors influencing residents' WSB, but the impact of the penalty on residents' WSB under the mandatory policy in China, has been less studied. Second, most studies on penalty for improper waste disposal practices have been done from an economic perspective, few studies explored the mediation effect of personal norm between penalty and WSB, and even fewer considered the moderation effect of trust in authorities on the above relationships. Shaping the public's moral obligation to waste separation and trust in authorities plays an important role in the context of mandatory policy. Third, most relevant studies used hierarchical regressions to explore the moderate effect and moderated mediation effect, ignoring measurement errors in observed variables. This approach may result in biased parameter estimates [31].

With respect to existing literature, this paper first investigated the impact of penalty on residents' WSB based on deterrence theory and normative activation model. Then, the mediation role of personal norm and the moderation effect of trust in authorities were analyzed using SEM and the latent moderated mediation model, which takes into account the measurement error of the observed variables and can reduce estimation bias.

Theoretical Background and Research Hypotheses

Deterrence Theory

Becker proposed the economic deterrence model in 1968, which asserts that violations depend on the certainty, severity, and celerity of sanction [32]. The certainty is the likelihood that the crime will be discovered and punished; the severity refers to the harshness of punishment for non-compliance; the celerity reflects the timeliness of punishment execution. Deterrence theory was initially applied in the fields of law and crime [33], some scholars then extended it to the areas of pro-social and pro-environmental behavior, such as information security behavior [34], environmental monitoring [35], and households waste recycling [36].

Generally, penalty certainty and penalty severity were associated with compliance behavior, while penalty celerity was correlated with non-compliance behavior [37, 38]. This study aims to explore the impact of penalty on compliance behavior with the mandatory waste separation policy, thus, penalty celerity was not covered.

Some studies showed that penalty certainty and penalty severity positively affected compliance behavior [38]. Residents may separate their wastes for fear of being fined under the mandatory policy [30, 36]. If the penalty certainty and penalty severity are high, peoples are more likely to comply with the rule and participate in waste separation. Thus, the following hypotheses were proposed:

H1: Penalty certainty positively affected WSB.

H2: Penalty severity positively affected WSB.

Normative Activation Model

The normative activation model proposed by Schwartz [39] assumes that personal norm is a direct predictor of an individual's behavior. Personal norm refers to individuals' perception of moral responsibility and obligation to perform a certain behavior. The theory has been widely employed to explore determinants of WSB [40, 41]. Once peoples form a moral obligation and think they have a moral obligation to sort waste, they will be more likely to participate in waste separation as required [42]. Thus, the following hypothesis was proposed:

H3: Personal norm positively affected WSB.

The penalty can deter residents from engaging in illegal behavior, as well as having the ability to communicate moral norms [43]. For example, Wang and Feng [44] showed that penalties can shape residents' moral norms about waste separation. Penalties convey to the public that compliance with waste separation rules is moral, and non-compliance is immoral [44]. Penalty severity generally conveys how immoral it is to violate the rules [43]. In other words, a severe penalty

communicates a stronger moral norm. Therefore, we proposed the following hypotheses:

H4: Penalty certainty positively affected personal norm.

H5: Penalty severity positively affected personal norm.

Given the preceding statement, which discusses the influence of penalty on personal norm, and the positive relationship between personal norm and WSB, it is logical that personal norm would exert the mediation effect between penalty and WSB. Penalty certainty and penalty severity may positively influence residents' WSB by motivating their personal norm to waste separation. Therefore, the following hypotheses were proposed:

H6: Personal norm mediated the relationship between penalty certainty and WSB.

H7: Personal norm mediated the relationship between penalty severity and WSB.

Trust in Authorities

Trust in authorities means that the local authorities are competent in waste separation management [45], which is reflected in two aspects. The first aspect is associated with the trustworthiness for the waste management system. The process of waste management involves several steps, such as source separation, collection, and transportation [46, 47]. If residents sort their waste at source and then find the separated waste being mixed during transportation, they will be less enthusiastic about separating waste [48]. The second aspect is associated with trust in the local government to seriously enforce penalties for violations [45]. The willingness of residents to comply with mandatory waste separation policy is closely related to the fairness and objectivity of the authorities in enforcing penalties [49]. Residents with higher trust in authorities believe that the waste management system and penalty are effective, then they are more likely to sort waste when perceived penalty certainty and penalty severity. Therefore, the following hypotheses were proposed:

H8: Trust in authorities moderated the relationship between penalty certainty and WSB. The higher the trust in authorities, the stronger the impact of penalty certainty on WSB.

H9: Trust in authorities moderated the relationship between penalty severity and WSB. The higher the trust in authorities, the stronger the impact of penalty severity on WSB.

An individual with higher trust in authorities is more likely to accept the information conveyed by authorities, and form higher personal norm to waste separation. A severe penalty is more conducive to activating personal moral norms than a mild one. However, it has been argued that this viewpoint was based on the assumption that the public trusts the authorities. For instance, Mulder et al. [50] stated that, only when students have a high level of trust in the

educational institution, a severe penalty was more likely to activate students' moral norms than a mild penalty. Thus, the following hypotheses were proposed:

H10: Trust in authorities moderated the relationship between penalty certainty and personal norm. The higher the trust in authorities, the stronger the impact of penalty certainty on personal norm.

H11: Trust in authorities moderated the relationship between penalty severity and personal norm. The higher the trust in authorities the stronger the impact of penalty severity on personal norm.

H6-7 inferred that penalty certainty and penalty severity positively affected WSB through the mediation role of personal norm, and H10-11 proposed the moderation effect of trust in authorities. By integrating the above hypotheses, we inferred that trust in authorities moderated the mediation effect presented by H6-7. Thus, the following hypotheses were proposed:

H12: Trust in authorities moderated the mediation effect of personal norm between penalty certainty and WSB. The higher the trust in authorities, the stronger the mediation effect.

H13: Trust in authorities moderated the mediation effect of personal norm between penalty severity and WSB. The higher the trust in authorities, the stronger the mediation effect.

Based on the above theoretical foundation and research hypotheses, a research framework was constructed to explain the impact of penalty on residents' WSB from the aspects of certainty and severity (Fig. 1).

Materials and Methods

Questionnaire Design

Most measure items in this study were adapted from existing studies to ensure reliability and validity. The questionnaire consisted of three parts: demographic variables, WSB, and possible drivers. The demographic variables include gender, age, education level, etc. Using a Likert five-point scale ranging from "never" to "always", we assessed respondents' WSB by asking how often they separated their waste. The possible drivers comprised penalty certainty, penalty severity, trust in authorities and personal norm, which were measured through a Likert five-point scale ranging from "completely disagree" to "completely agree". In addition, an instructed question (i.e., Please select "completely agree" for this question) was designed to test which respondents were paying attention to this survey [51].

To fit the study context, we revised minor changes in the statements and language of the questionnaire based on suggestions from several professors. Then, a pilot study with 112 respondents was performed through an online survey in December 2021. According to the

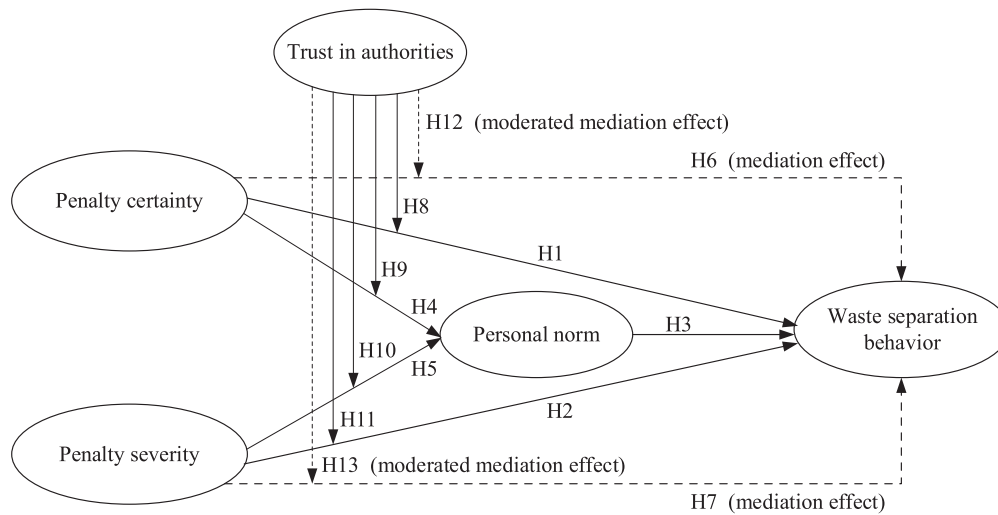


Fig. 1. Theoretical framework.

feedback from the pilot survey, we further modified inappropriate and unclear wording, and deleted the invalid measurement items. Finally, the formal

questionnaire consisting of 28 questions was obtained, and measurement items of latent variables were listed in Table 1.

Table 1. Constructs and measurement items.

Variables	Measurement items	Sources
Penalty certainty (PC)	PC1: If I fail to separate waste, it will be detected.	[30, 36]
	PC2: If I fail to separate waste, the likelihood that I would be fined is high.	
	PC3: If I fail to separate waste, I will be fined 50 yuan.	
	PC4: There will be a supervisor or a volunteer to supervise the disposal of waste.	
	PC5: The waste collector will check whether the waste has been sorted before collection.	
Penalty severity (PS)	PS1: The penalty that follows when caught not separating waste, is severe.	[30, 50]
	PS2: I think the fine for unclassified behavior is high.	
	PS3: Being fined would bother me a lot.	
	PS4: Being fined would have a bad influence on my self-image.	
Trust in authorities (TA)	TA1: I trust that the local government is competent in waste separation management.	[45]
	TA2: I trust that the local government strictly enforces penalties for illegal behavior.	
	TA3: I trust that the penalty measures for waste separation are effective.	
	TA4: I trust that the waste will be sorted for transportation and disposal.	
Personal norm (PN)	PN1: I have a moral obligation to separate waste.	[19, 42]
	PN2: Not separating waste would violate my moral principles.	
	PN3: I feel obliged to separate waste in my daily life.	
	PN4: I think that each citizen is obliged to separate waste.	
Waste separation behavior (WSB)	WSB1: How often do you separate recyclable wastes (such as newspaper, plastic bottles)?	[13, 27]
	WSB2: How often do you separate kitchen wastes (such as leftovers, fruit residues)?	
	WSB3: How often do you separate hazardous wastes (such as battery, bulb)?	
	WSB4: How often do you separate other wastes (such as napkins, floor sweepings)?	
	WSB5: How often do you separate medical wastes (such as face mask, glove)?	

Data Collection Procedures

Zhengzhou City, as one of the 46 mandatory waste separation pilot cities in China, incorporated waste separation into the legal framework on December 1st, 2019. Individuals refusing to sort waste would be fined 50 yuan (about US\$ 7.465). Thus, Zhengzhou citizens were suitable for this study.

The online survey was conducted using convenience-based sampling. Wenjuanxing, a Chinese online survey platform, was employed to create the questionnaire, and the link to the questionnaire was sent to potential respondents who had contact with team members via WeChat. To avoid receiving responses with incomplete answers and those from the same respondent, all questions are required, and each WeChat user can only submit the questionnaire once. Monetary rewards were offered to respondents after they submitted their questionnaires. From January to March 2022, we distributed 1038 questionnaires.

The following three kinds of questionnaires were considered invalid responses. First, the time taken to complete this questionnaire was less than 56 seconds,

because Huang et al. [52] suggested that the time taken to answer each question should not be less than 2 seconds (28 questions in our questionnaire). Second, almost all answers for measurement items were the same. Third, the respondents did not follow the instruction for the instructed item, i.e., they did not choose to “completely agree” for the instructed question [51]. After invalid questionnaires were discarded, we received a total of 628 valid questionnaires. The availability response rate was 60.5%.

Data Analysis

SPSS 24.0 and Mplus 8.3 were utilized to analyze the data. Given that all variables (excluding demographic variables) were measured using self-report scales at the same time, the problem of common method variance (CMV) may affect the results. Therefore, we first assessed the influence of CMV using Harman’s single-factor test and the unmeasured latent method factor approach. Second, the survey data were tested for reliability and validity. Then, descriptive statistics analysis was performed. Finally, the SEM, moderated

Table 2. Validity and reliability testing.

Variables	Items	Factor loading	Cronbach’s α	CR	AVE
Penalty certainty (PC)	PC1	0.662	0.914	0.915	0.686
	PC2	0.824			
	PC3	0.915			
	PC4	0.928			
	PC5	0.784			
Penalty severity (PS)	PS1	0.632	0.824	0.828	0.549
	PS2	0.759			
	PS3	0.808			
	PS4	0.752			
Trust in authorities (TA)	TA1	0.890	0.927	0.927	0.762
	TA2	0.873			
	TA3	0.882			
	TA4	0.845			
Personal norm (PN)	PN1	0.781	0.889	0.891	0.672
	PN2	0.802			
	PN3	0.831			
	PN4	0.862			
Waste separation behavior (WSB)	WSB1	0.672	0.878	0.878	0.592
	WSB2	0.812			
	WSB3	0.719			
	WSB4	0.832			
	WSB5	0.801			

mediation model, and bootstrapping analysis based on 2000 bootstrap samples were employed to test hypotheses proposed in this study.

Results

Common Method Variance

The result indicated that the first and largest factor in the exploratory factor analysis only explained 29.37% loading (< 40%). A common method factor was added to the five-factor model including penalty certainty, penalty severity, trust in authorities, personal norm, and WSB. The model fit indices were $\chi^2 = 283.899$, $df = 177$, $\chi^2/df = 1.604$, $RMSEA = 0.031$, $CFI = 0.988$, $TLI = 0.984$, $SRMR = 0.025$, which were similar to those of the five-factor model without method factor ($\Delta\chi^2/df = 0.502$, $\Delta CFI = 0.014$, $\Delta TLI = 0.014$, $\Delta RMSEA = 0.011$, $\Delta SRMR = 0.015$). Thus, there was no severe CMV in this study.

Validity and Reliability

As illustrated in Table 2, the Cronbach's α coefficients of each variable were between 0.824 and 0.927, and the value of composite reliability (CR) ranged from 0.828 to 0.927. These results were above the threshold value suggested by Fornell and Larcker [53], indicating that the survey data had good reliability.

The factor loadings of each measurement item were higher than 0.6 [54], and all values of average variance extracted (AVE) exceed 0.5 [53]. Therefore, the measurements of latent variables had good convergence validity. The results of confirmatory factor analysis were presented in Table 3. The five-factor model displayed a good fit with the data ($\chi^2 = 419.137$, $df = 199$, $\chi^2/df = 2.106$, $RMSEA = 0.042$, $CFI = 0.974$, $TLI = 0.970$, $SRMR = 0.040$), indicating that the model had good structural validity. As can be seen from Table 3, the model fit indices became increasingly worse from the five-factor model to the one-factor model, demonstrating that all variables had good discriminant validity.

Table 3. Confirmatory factor analysis.

Model	Factor	χ^2	df	χ^2/df	RMSEA	CFI	TLI	SRMR
Five-factors	PC, PS, TA, PN, WSB	419.137	199	2.106	0.042	0.974	0.970	0.040
Four-factors	PC+PS, TA, PN, WSB	1193.537	203	5.879	0.088	0.885	0.869	0.080
Three-factors	PC+PS+TA, PN, WSB	3159.373	206	15.337	0.151	0.656	0.615	0.138
Two-factors	PC+PS+TA+PN, WSB	4387.923	208	21.096	0.179	0.514	0.460	0.160
One-factor	PC+PS+TA+PN+WSB	5469.016	209	26.167	0.200	0.388	0.324	0.173

Note: PC: penalty certainty; PS: penalty severity; TA: trust in authorities; PN: personal norm.

Descriptive Statistics Analysis

The demographic characteristics of respondents were presented in Table 4. Of the total samples, 46.7% were male, 53.3% were female. Respondents aged under 25, 26-30, 31-40 and 41-50 years old accounted for 30.1%, 34.4%, 20.5% and 11.6%, respectively. In terms of education level, 15.4% of respondents had an associate degree, nearly half (48.1%) had a bachelor's degree, 17.2% had a master's degree, and only 7.8% had a Ph.D. Government or institutional staff, company manager, general worker and service personnel, self-employment venture, student, and retirement or laid-off worker accounted for 13.7%, 14.8%, 42.2%, 8.4%, 17.7%, and 1.9%, respectively. Respondents with a monthly income of 8000-10000 and above 10001 yuan were relatively few, accounting for 12.7% and 11.6%, respectively. About one-third of surveyed residents had a monthly income of below 4000 yuan. Respondents with monthly incomes of 4001-6000 and 6001-8000 yuan accounted for 22.6% and 19.6%, respectively. These characteristics were basically in line with the demographic profile of Zhengzhou residents, indicating that the samples were well representative.

Hypothesis Testing

Total Effect

The SEM consisting of penalty certainty, penalty severity, and WSB was analyzed to validate total effects. The model fit was compliant ($\chi^2 = 162.873$, $df = 74$, $\chi^2/df = 2.201$, $RMSEA = 0.044$, $CFI = 0.982$, $TLI = 0.978$, $SRMR = 0.032$). The result revealed that penalty certainty positively influenced WSB ($\beta = 0.385$, $p < 0.01$), supporting H1. Penalty severity positively affected WSB ($\beta = 0.123$, $p < 0.05$), supporting H2.

Mediation Effect

To examine Hypotheses 3-7, the SEM with personal norm as a mediation variable was analyzed. The model fit was well with data, i.e., $\chi^2 = 317.908$, $df = 129$, $\chi^2/df = 2.464$, $RMSEA = 0.048$, $CFI = 0.971$, $TLI = 0.966$, $SRMR = 0.043$. The result demonstrated that the impact of personal norm on WSB was

Table 4. Demographic characteristics of respondents (N = 628).

Demographic variables		Frequency	Percentage (%)
Gender	Male	293	46.7
	Female	335	53.3
Age	Under 25	189	30.1
	26-30	216	34.4
	31-40	129	20.5
	41-50	73	11.6
	51 or above	21	3.4
Education level	Senior high school or below	72	11.5
	Associate degree	97	15.4
	Bachelor's degree	302	48.1
	Master's degree	108	17.2
	PhD	49	7.8
Occupation	Government or institutional staff	86	13.7
	Company manager	93	14.8
	General worker and service personnel	265	42.2
	Self-employment venture	53	8.4
	Student	111	17.7
	Retirement or laid-off worker	12	1.9
	Others	8	1.3
Monthly income (RMB)	Below 4000	210	33.4
	4001-6000	142	22.6
	6001-8000	123	19.6
	8001-10000	80	12.7
	Above 10001	73	11.6

Table 5. Results of mediation effect.

	Estimate	S.E.	P-value	95 % BCCI
Total effect				
Penalty certainty → WSB	0.385	0.056	0.000	[0.288, 0.508]
Penalty severity → WSB	0.123	0.056	0.029	[0.018, 0.244]
Indirect effect				
Penalty certainty → Personal norm → WSB	0.049	0.020	0.012	[0.019, 0.095]
Penalty severity → Personal norm → WSB	0.033	0.017	0.057	[0.009, 0.081]
Direct effect				
Penalty certainty → WSB	0.337	0.055	0.000	[0.246, 0.461]
Penalty severity → WSB	0.091	0.054	0.090	[-0.012, 0.199]

significant ($\beta = 0.174, p < 0.01$), supporting H3. Penalty certainty ($\beta = 0.282, p < 0.01$) and penalty severity ($\beta = 0.187, p < 0.05$) positively influenced personal norm, supporting H4-5.

Bootstrapping analysis with bias-corrected confidence estimates was employed to further estimate the mediation effect of personal norm, and the results were listed in Table 5. A significant mediation effect could be verified if the 95% bias-corrected bootstrapped confidence interval (BBCI) of the indirect effect excludes 0. The results demonstrated that the indirect effect of personal norm between penalty certainty and WSB was significant (indirect effect = 0.049, BBCI = [0.019, 0.095]). The direct effect of penalty certainty on WSB also was significant (direct effect = 0.337, BBCI = [0.246, 0.461]). Therefore, personal norm partly mediated the relationship between penalty certainty and WSB, supporting H6. The indirect effect of personal norm between penalty severity and WSB was supported (indirect effect = 0.033, BBCI = [0.009, 0.081]). The direct effect of penalty severity on WSB was not verified because the BBCI contained 0 at a 95% significant level (BBCI = [-0.012, 0.199]). Therefore, personal norm fully mediated the relationship between penalty severity and WSB, supporting H7.

Moderation Effect

A moderated mediation model with latent interactions was estimated to verify H8-13. According to the recommendation by Maslowsky et al. [55], the model without interaction terms was regarded as a baseline model (Model 0), which had well fit indices ($\chi^2/df = 2.106, RMSEA = 0.042, CFI = 0.974, TLI = 0.970, SRMR = 0.040$). Then, the moderated mediation model with latent interaction terms (Model 1) was analyzed. The relative fit of Model 1 versus Model 0 was obtained through a log-likelihood ratio test. The log-likelihood difference value was 29.350. Based on a chi-square distribution ($df = 4$), the log-likelihood ratio test was significant ($p < 0.01$), suggesting that Model 1 had a better fit than Model 0. Therefore, the moderated mediation model with latent interaction terms was considered a well-fitting model.

The results indicated that the interaction item between penalty certainty and trust in authorities had a significant impact on WSB ($\beta = 0.107, p < 0.05$). The simple slope test recommended by Hayes and Rockwood [56] was conducted to interpret the moderation effect of trust in authorities. One standard deviation (SD) above the mean represents a high level of trust in authorities, and one SD below the mean represents a low level of trust in authorities. As shown in Fig. 2, when residents' trust in authorities was high, the impact of penalty certainty on WSB was stronger ($\beta = 0.456, p < 0.01$); when residents' trust in authorities was low, the impact of penalty certainty on WSB was weaker ($\beta = 0.242, p < 0.01$). These results suggested that the positive relationship between penalty certainty and

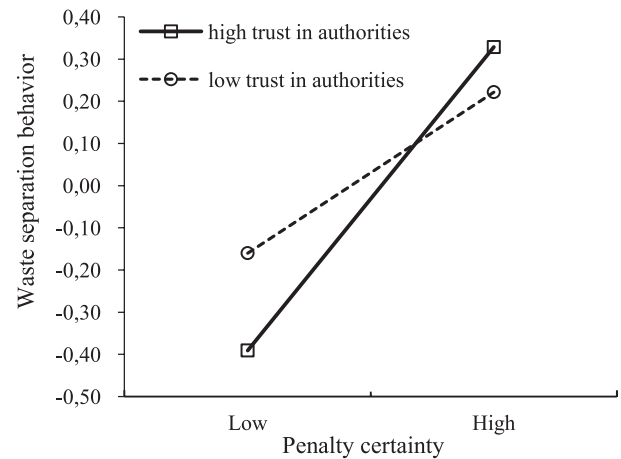


Fig. 2. Moderating effect of trust in authorities on the relationship between penalty certainty and waste separation behavior.

WSB was stronger when trust in authorities was high, supporting H8.

The interaction item between penalty severity and trust in authorities had no significant impact on WSB ($\beta = 0.037, p > 0.05$). This implied that the moderation effect of trust in authorities on the relationship between penalty severity and WSB was insignificant, not supporting H9.

The interaction item between penalty certainty and trust in authorities had a positive impact on personal norm ($\beta = 0.278, p < 0.05$). As presented in Fig. 3, when residents have high trust in authorities, the influence of penalty certainty on personal norm was stronger ($\beta = 0.436, p < 0.01$); when residents have low trust in authorities, the influence of penalty certainty on personal norm was weaker ($\beta = 0.155, p < 0.05$). These results demonstrated that when residents' trust in authorities was high, the positive relationship between penalty certainty and personal norm was stronger, supporting H10.

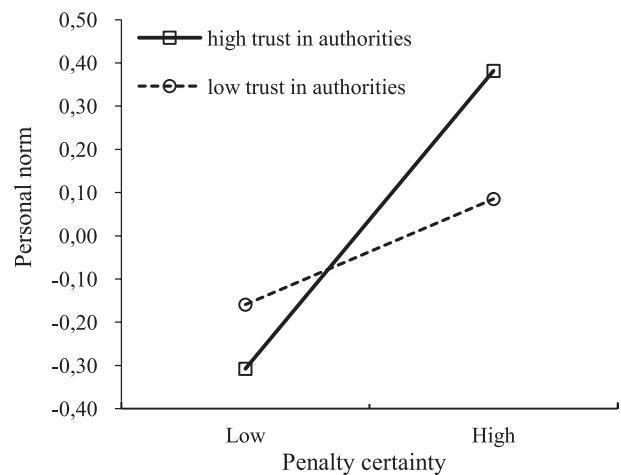


Fig. 3. Moderating effect of trust in authorities on the relationship between penalty certainty and personal norm.

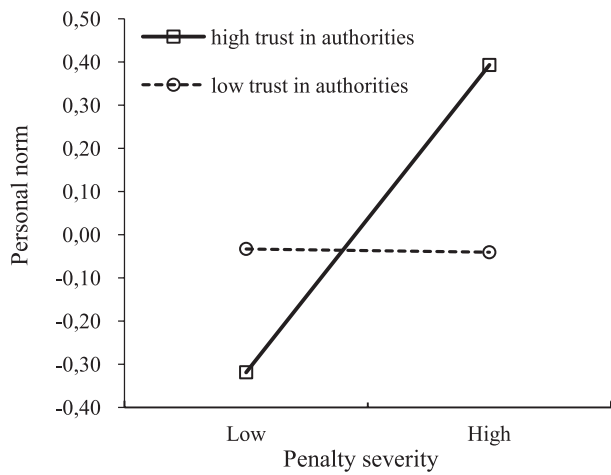


Fig. 4. Moderating effect of trust in authorities on the relationship between penalty severity and personal norm.

The interaction item between penalty severity and trust in authorities positively affected personal norm ($\beta = 0.278, p < 0.01$). It can be seen from Fig. 4, for residents with high trust in authorities, the higher the penalty severity, the higher the personal norm ($\beta = 0.551, p < 0.01$). However, for residents with low trust in authorities, penalty severity had no significant impact on personal norm ($\beta = -0.006, p > 0.05$). These results supported H11.

Moderated Mediation Effect

Table 6 showed the results of moderated mediation effect. When residents' trust in authorities was high, the mediation effect of personal norm between penalty certainty and WSB was 0.059, and the 95% BBCI was [0.015, 0.129]. When residents' trust in authorities was low, the mediation effect was 0.021, and the 95% BBCI was [0.003, 0.056]. Both mediation effects under conditions of high and low trust in authorities were significant because 95% BBCIs excluded 0. The difference between the mediation effects under high and low trust in authorities was also significant

(BBCI = [0.006, 0.106]), which suggested that the mediation effect of personal norm was moderated by trust in authorities. These results revealed that the higher the trust in authorities, the stronger the mediation effect of personal norm between penalty certainty and WSB, supporting H12.

As listed in Table 6, when residents' trust in authorities was high, the mediation effect of personal norm between penalty severity and WSB was 0.075, and 95% BBCI was [0.023, 0.177], which excluded 0. However, when residents' trust in authorities was low, the mediation effect was not significant because the 95% BBIC included 0 (BBCI = [-0.026, 0.023]). Furthermore, the difference of mediation effects under the conditions of high and low trust in authorities was significant (BBCI = [0.006, 0.106]). This implies that as residents' trust in authorities increases, the mediation effect of personal norm between penalty severity and WSB changes from insignificant to significant, supporting H13.

Discussion

Based on the results above, three main findings were highlighted.

First, residents' perceived penalty certainty and penalty severity positively affected their WSB in Zhengzhou, China. The result is consistent with that of Ogiri et al. [30] who indicated that Malaysian residents' compliance behavior with a waste recycling program was positively related to penalty certainty and penalty severity. This finding confirms the applicability of deterrence theory in the area of compliance with the waste separation policy. And, penalty certainty had a greater impact on residents' WSB than penalty severity, which is in line with Ogiri et al. [30]. This finding implies that no matter how severe the penalty was, residents were likely to follow mandatory waste separation policies when the likelihood of penalty for non-compliance was high. As reported by Nagin [57], a more effective deterrence was derived from the penalty certainty, not the severity of the ensuing legal

Table 6. Results of moderated mediation effect.

	Estimate	S.E.	95 % BBCI
Penalty certainty → Personal norm → WSB			
High trust in authorities (+1SD)	0.059	0.029	[0.015, 0.129]
Low trust in authorities (-1SD)	0.021	0.013	[0.003, 0.056]
Difference	0.038	0.024	[0.006, 0.106]
Penalty severity → Personal norm → WSB			
High trust in authorities (+1SD)	0.075	0.037	[0.023, 0.177]
Low trust in authorities (-1SD)	-0.001	0.012	[-0.026, 0.023]
Difference	0.076	0.037	[0.024, 0.177]

consequences. Therefore, to effectively guide residents to separate waste as required, it is crucial to increase the probability of detecting violations rather than increasing the amount of fine.

Second, personal norms play the mediating effect between penalty certainty (or penalty severity) and WSB. Residents' perceived penalty certainty and penalty severity can activate personal norm on waste separation, which echoes the result of Martin et al. [58] who found that legal penalty positively affected personal norm on illegal anti-ecological behavior. Personal norm, as a main predictor of WSB, mediated the relationship between penalty and WSB. Penalty certainty and penalty severity have a positive effect on personal norms, which in turn positively influence residents' WSB. This result validates the integrated framework of deterrence theory and normative activation model. Interestingly, residents' perceived penalty certainty not only indirectly positively affected WSB by activating personal norm, but also directly affected WSB. However, residents' perceived penalty severity only had an indirect impact on WSB through the mediating role of personal norm. The reason for this difference may be that penalty certainty is more likely than penalty severity to make people comply with regulations to perform pro-environmental behaviors.

Third, the moderating effect of trust in authorities was verified. Trust in authorities positively moderated the relationship between penalty certainty and WSB. The result agrees with the finding of Chen et al. [59] who found that trust moderated the relationship between residents' cognition and WSB. Trust in authorities positively moderated the relationship between penalty certainty and personal norm, which implies that for residents with higher trust in authorities, the impact of penalty certainty on personal norm was stronger. Trust in authorities positively moderated the relationship between penalty severity and personal norm, which is consistent with the conclusion made by Mulder [43]. If residents have a high level of trust in authorities, severe penalties were more likely to activate their personal norm than mild ones. On the contrary, if residents have a low level of trust in authorities, penalty severity may not activate their personal norm. The possible explanation is that people with low trust in authorities may resent penalties, and fail to accept the moral norms conveyed by the authorities. Trust in authorities positively moderated the mediation effect of personal norm, which suggests that when residents have high trust in authorities, the mediation role of personal norm was stronger. The findings suggest that when implementing the mandatory waste separation policy, the government should ensure the effectiveness of the policy to enhance residents' trust in the authorities.

Trust in authorities was integrated into the comprehensive framework combining deterrence theory and norm activation model, which provides theoretical support for mandatory environmental policy

management. Meanwhile, primary data from residents of Zhengzhou, China, were used to confirm the above theoretical model and provide a reference for policy makers to guide residents to separate waste at source. These are precisely the strengths of this study. However, there are two limitations of this paper, which can be improved in further studies. The first aspect is that this study includes only limited factors that influence the public's WSB. The second aspect is that the long-term effects of penalty policies on WSB are not explained in this study.

Conclusions

Based on deterrence theory and normative activation model, this paper investigated the impact of penalty on residents' WSB from two perspectives: penalty certainty and penalty severity, and analyzed the mediation of personal norm and the moderating effect of trust in authorities. The contributions of the present study are as follows. First, a new theoretical framework that explains the impact of penalty on residents' WSB was constructed by combining deterrence theory and norm activation model. Second, the moderating effect of trust in authorities between penalty certainty and WSB was confirmed, which enriches the research on WSB and emphasizes the importance of trust in authorities. Third, the findings of this study provide a reference for waste separation policy makers. This paper presents a new perspective and theoretical guidelines for the local government to improve residents' WSB in China and offers useful insights into waste separation management. The findings are as follows.

(1) Penalty certainty and penalty severity positively influenced WSB through the mediating role of personal norm. Penalty certainty had a direct effect on WSB, whereas penalty severity did not.

(2) Trust in authorities moderated the relationship between penalty certainty and WSB. The higher the residents' trust in authorities, the stronger the impact of penalty certainty on WSB.

(3) Trust in authorities moderated the relationship between penalty certainty and personal norm, as well as the relationship between penalty severity and personal norm. The higher the residents' trust in authorities, the stronger the impacts of penalty certainty and penalty severity on personal norm.

(4) The mediating effect of personal norm was moderated by trust in authorities. The higher the trust in authorities, the stronger the mediating effect of personal norm.

Although the findings were drawn based on the data from respondents in Zhengzhou, China, they are still useful for authorities in other pilot cities for mandatory waste separation. In addition, the findings provide a reference for other developing countries to develop waste separation policies. In light of the above conclusions, some recommendations were made for

guiding residents to comply with the mandatory waste separation policy.

(1) The probability of penalty for non-compliance should be emphasized. The government can further clarify the responsibility of community property management for waste separation. By assigning specially-assigned persons and volunteers, peoples' waste disposal behavior should be carefully supervised to increase the likelihood of detecting non-compliance. At the same time, the smart waste bin with the function of recording violations should be widely installed in residential areas to enable targeted supervision and education.

(2) Residents' trust in the authorities of waste separation management should be valued. In order to avoid the ineffective connection, the government should make improvements in the processes of waste collection, transportation, and recycling. For example, the government could issue more detailed regulations that define the responsibilities of the relevant departments and enterprises. A performance appraisal should also be developed, and the results were released to the public on a regular basis. The authorities should adopt an open and transparent way to implement penalties for violations. Only in this way will the deterrence of penalty be effective.

(3) Residents' personal norm to waste separation should be enhanced in many aspects. Communities can inform residents that penalty exists by posting notices to remind them to comply. It is necessary to strengthen waste separation publicity and education to form long-term and stable personal norm to waste separation. In order to form a positive social atmosphere, the government can release public service announcements related to waste separation through new media platforms, such as short-form videos, official accounts, and subway advertising.

This paper has certain limitations, which can be addressed in future works. First, we mainly investigated the impacts of penalty certainty, penalty severity on WSB, and moderating effect of trust in authorities under the context of mandatory policies in Zhengzhou, China. Future research could introduce other variables into the research framework. Second, this study only employed cross-sectional survey data, cannot explain the long-term effects of penalty on residents' WSB. A longitudinal study can be conducted in subsequent research.

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Conflict of Interest

The authors declare no conflict of interest.

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