Desalination and Water Treatment
www.deswater.com
doi: 10.5004/dwt.2023.30109

316 (2023) 725–735
December

Exploring the household wastewater sorting intention of rural residents by PLS-SEM: an empirical study in Jiangsu Province, China

Na Wang[a, c, d]*, Mingyu Yang[a, c], Hanqi Liu[c], Zhiqiang Li[a], Chenyu Wang[c], Xing Jin[a], Haoran Sun[c], Xiangfei Li[e]*

[a]*Institute of Climate and Environment Governance, Nanjing University of Information Science and Technology, Nanjing 210044, China, email: 002774@nuist.edu.cn*
[b]*Institute of Environment and Health, Nanjing University of Information Science and Technology, Nanjing 210044, China*
[c]*School of Law and Public Affairs, Nanjing University of Information Science and Technology, Nanjing 210044, China*
[d]*College of Economics and Management, Nanjing Agricultural University, Nanjing 210095, China*
[e]*College of Food Science and Engineering, Nanjing University of Finance and Economics, Nanjing 210003, China*

Received 13 March 2023; Accepted 28 November 2023

ABSTRACT

This study aims to assess the household waste sorting intention of Chinese rural residents, and detect impacts of the main determinants of their sorting behavior applying partial least squares structural equation modeling (PLS-SEM). A modified model of the theory of planned behavior was established. Three factors, that is, governmental policy, awareness of sorting necessity and ecological value, are added to the modified model and subject norm and perceived behavioral control are set as formative indicators. The model is empirically investigated by questionnaire survey data collected from 322 respondents in Jiangsu Province, China (a response rate of 92%). The result shows that awareness of sorting necessity and ecological value have significantly positive effects on the household waste sorting intention of rural residents. Subject norm and awareness of sorting necessity are the two most important determinants. Government policies have no direct influence on the sorting intention, but it indirectly affect sorting intention through four mediating variables, namely sorting attitude, subject norm, awareness of sorting necessity and ecological value, among which the paths mediated by subject norm and awareness of sorting necessity are extremely crucial. Advices for improving the household waste sorting intention of rural residents are proposed. Limitations of this study and suggestions for further research are comprehensively discussed.

Keywords: Waste sorting intention; Rural residents; Government policy; Mediating effect; PLS-SEM

1. Introduction

Chinese household waste of rural residents is mainly categorized into 4 groups, kitchen waste, recyclable waste, hazardous waste, and other waste [1]. Improper disposal of these waste leads to a series of environmental hazards such as water and soil pollution, infectious diseases, and greenhouse gas emissions, posing a negative effect on the living standard of rural residents. Along with the rapid development of the rural economy, pollutions caused by household waste severely hinder the improvement of the living standard of rural residents [2]. More importantly, building a pleasant living environment is one of the key goals in the rural vitalization of China. However, a considerable amount of waste is still dumped in landfills or incinerated directly in China. According to the Ministry of Housing and Urban-Rural Development, the amount of rural household waste has achieved 1.5 Mt in 2015 with an annual growth

* Corresponding authors.

rate of about 8% to 16%, while the average recovery rate is only 5% [3,4]. Studies have predicted that the amount of rural household waste in China would be twice as much as that of the United States by the year 2030 [5].

Human behavior greatly affects the solving of household waste pollution from the root [6]. If rural residents sort household waste positively, waste recycling can be carried out easily. Waster classification, that is, putting different kinds of garbage into different trashing, facilitates the reutilization of waste via ways of cleaning, shipping, and recycling. Facing the serious situation of household waste pollution, Chinese governments at both central and local levels have issued a series of policies to stimulate source sorting of rural household waste to achieve the reduction, harmless, and recycling of garbage. For example, the National Development and Reform Commission and the Ministry of Housing and Urban-Rural Development issued an implementation plan for a household waste classification system. Waste treatment has achieved great results in Jiangsu Province. The residents are forced to sort household waste according to the implementation plan for urban and rural household garbage treatment. The plan put forward the coordinated urban and rural household garbage collection, transport, and treatment system as "group cleaning, village collection, town transit, county (city) centralized processing". Residents can also get small gifts through the ways of green accounts or credit exchange when they conduct recycling household waste in Sihong County.

Recycling behaviors have been widely detected focusing on different groups of people, such as food waste management [7,8], waste recycling behavior, and waste management in industry [9–14]. However, only a very small number of previous studies have explored household waste source sorting [15]. Little attention is paid to external government factors, especially the waste-sorting behaviors of Chinese rural residents. Thus, the main purpose of this study is to detect the main determinants of the intention of rural residents to sort household waste by applying partial least squares structural equation modeling (PLS-SEM). Taking the rural residents of Jiangsu as an example, this study evaluated the factors affecting household waste sorting behavior to various degrees. Through a thorough and in-depth exploration of what stimulates the rural residents to sort household waste, this study provided suggestions for Chinese policymakers to comprehensively regulate rural household waste pollution.

2. Model and hypotheses

2.1. The modified TPB model

Based on the analysis of the influencing factors of the household waste sorting behavior of Chinese rural residents, a modified theory of planned behavior (TPB) model is applied. The TPB model, a most common method for detecting pro-environment behavior, evolved from the theory of reasoned action proposed by Ajzen [16–18]. As TPB proposed, attitudes, subjective norms, and perceived behavior control affect the individual behavioral intention which affects the behavioral performance. Besides, perceived behavior control can also influence behavioral performance directly. Behavioral performance refers to the individual's actual action. Behavioral intention refers to the willingness or determination of an individual to take a particular action. Attitude is rendered as to an individual's feeling towards a given behavior, either positive or negative. Subjective norms mean the social pressure upon an individual to adopt a given behavior or not. Perceived behavioral control (PBC) refers to the previous experience and expectations as obstacles [12]. TPB has been widely used to explain an individual's behavior as supported by a meta-analysis [10,14,19]. However, TPB alone is incomplete, and extra factors need to be studied to enhance the validity of this study [20–23].

Stern and Oskamp proposed an environmental behavior model, indicating that environmental behavior depends on combined roles from a series of internal and external factors [24,25]. External factors generally refer to factors such as social institution and economic incentives, and internal factors commonly refer to factors such as environmental attitudes, individual beliefs and values. Aiming at household waste recycling behavior, Guagnano et al. [26] proposed the theory of attitude, behavior, and condition (ABC) on the base of the theory of Stern and Oskamp [24,26]. The ABC theory indicates that household waste recycling behavior mainly depends on the individual's attitude and external conditions. External conditions mainly refer to the difficulty of behavior, laws and regulations, and economic conditions. The Theory of TPB was modified based on the ABC theory. As government policy plays a vital role in improving the environment, it is chosen as an external condition factor. The individual's ecological value and awareness of household waste sorting necessity are also included as social psychological factors, as shown in Fig. 1.

2.2. Research hypotheses

TPB has been widely used to evaluate recycling behaviors. Ru et al. [21], Hiselius and Rosqvist [17], Knussen et al. [27], and Armitage and Conner [19] used the efficacy of the TPB components to explain a wide range of intentions and behaviors. Chen [28] detected the influence factors on individual's sustainable travel behavior drawing on TPB; Wang et al. [12], Echegaray and Hansstein [29] and Wan et al. [30] applied TPB to e-waste recycling behavior; Best and Kneip [31], Knussen et al. [27], and Pakpour et al. [10] used TPB to study household waste recycling behavior. Attitude refers to an individual's positive or negative evaluation of a given behavior [18,20]. A positive attitude towards a certain pro-environmental behavior equals a stronger intention to conduct such behavior [21]. Wan et al. [22], Blok et al.[32], Yazdanpanah and Forouzani [33], and Greaves et al. [34] have demonstrated that individual attitude has a significant influence on the individual's recycling behavior, pro-environmental behavior, green product consumption, and others. PBC refers to the self-assessment of an individual's efficacy and control ability towards carrying out a given behavior [18,35], which is widely recognized as a vital factor in deciding behavioral intention [36]. Individuals with stronger self-control have a stronger intention to conduct a given pro-environmental behavior. When it comes to household waste behavior, if individuals have relevant skills and feel household waste sorting is easy, their willingness to sort household

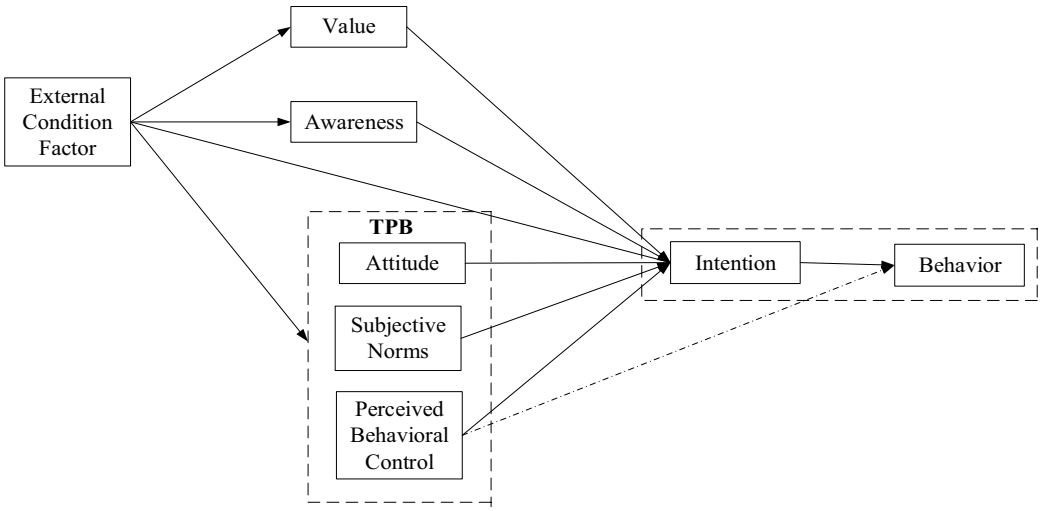

Fig. 1. The model of modified TPB.

waste, that is, their sorting intentions, will be stronger. Originally, subjective norm referred to the social pressure upon an individual [18]. Blok et al. [32], De Leeuw et al. [23] Wang et al. [20] and Ru et al. [21] indicated that subjective norms can impact the individual's pro-environmental behavior. Individuals find it much easier to engage in a specific behavior when they perceive stronger expectations and performance from others [20,21,23,32,34,35]. That is, if individuals realize that their important friends or relatives think that they should sort household waste, they are more naturally to form household waste sorting intentions. Thus, the hypotheses was proposed as follows.

- H_1. Sorting attitude positively affects the residents waste-sorting intention.
- H_2. Subjective norm positively affects the residents' waste-sorting intention.
- H_3. Perceived behavioral control positively affects the residents waste-sorting intention.

According to the ABC theory, an individual's waste-sorting behavior is determined by his/her attitude and external condition factors. In China, government policy is an important factor in controlling waste pollution. There are many kinds of governance models to aim at recycling rural household waste, which mainly rely on government leading roles. Many Chinese local governments adopt the waste management pattern of village collection, town transit and city process, and sets up cleaners. The local governments also formulate village regulations and establish reward and punishment mechanisms [37]. Thus, this study chose government policy as an external condition factor. Many studies have focused on the relationship between policies and a specific behavior [15,38,39]. Wang et al. [12] detected the influence of publicity on the individual's sorting intentions of e-waste. Wen [3] elaborated the operation mechanism of the state-directed cooperative model to control household garbage in rural areas. Wang and He [40] also stated the policies of information spreading and economic incentives are two main factors in shaping specific environmental behavior. In addition, government factor affects the residents attitudes and subjective norms has to be detected. Hence, the hypotheses was proposed as follows:

- H_4. Government policy towards waste sorting positively affects the residents sorting intention.
- H_5. Government policy towards waste sorting positively affects the residents sorting attitude.
- H_6. Government policy towards waste sorting positively affects the residents subjective norm.
- $H_{5\text{-}1}$. As the mediating variable, the residents sorting attitude can mediate the impact of government policy on their sorting intention.
- $H_{6\text{-}1}$. As the mediating variable, the residents subjective norm can mediate the impact of government policy on their sorting intention.

Human values can be defined as desirable goals that guide people's life [41]. In general, human values are divided into three value orientations (biospheric, egoistic, and altruistic), of which ecological value could reflect the environmental behavior tendency efficiently [42]. Obeng and Aguilar [43], Wang et al. [44] and Laroche et al. [45] declared a significant relationship between ecological values and specific pro-environmental behaviors. Waste sorting is a behavior that someone ought to do. Even with no immediate rewards, strong ecological values are still expected to affect the individual's attitude and drive their recycling behavior. Awareness of related knowledge about a specific behavior necessity is considered another important determinant of environmental behaviors [46]. Many studies, such as those by Wang et al. [12] and Bhawal Mukherji et al. [47] have illustrated the significant effect of environmental protection knowledge level on modifying environmental behavior. Han et al. [48] indicated that villagers who were convinced great necessity of waster sorting had higher willingness and participation rates than those who did not [48]. As key determinants, ecological values and awareness of household waste sorting necessity are also influenced by government policies.

For example, public education or instructions on specific recycling behavior might impact the individual's attitude and awareness of household waste sorting [38,39]. Gao [49] also stated informal government factors, such as local rules and regulations and village self-governance policies, can cultivate rural residents to form good habits and environmental attitudes. So, the hypotheses was proposed as follows:

- H_7. Ecological value positively affects the residents' waste-sorting intention.
- H_8. Awareness of household waste sorting necessity positively affects the residents waste sorting intention.
- H_9. Government policy towards waste sorting positively affects the residents ecological value.
- H_{10}. Government policy towards waste sorting positively affects the residents awareness of household waste sorting necessity.
- $H_{9\text{-}1}$. As the mediating variable, the residents ecological value can mediate the impact of government policy on their sorting intention.
- $H_{10\text{-}1}$. As the mediating variable, the residents' awareness of household waste sorting necessity can mediate the impact of government policy on their sorting intention.

3. Research metrology

3.1. Measures

Sorting attitude(SA), awareness of waste sorting necessity(AW), government policy(GOV), ecological value(EA), subject norm(SU), perceived behavioral control(PBC), waste sorting intention(SI) were adopted as measurement items based on previous researches by Wang et al.[12], Ru et al.[21], Xia et al.[30], Guo et al.[49], Wan et al.[30], Klöckner [52], Halvorsen [53], Sagie et al.[54], Francis et al.[55], Tonglet et al. [56], and Laroche et al. [45]. The questionnaire was designed and divided into three parts. The first part deals withthe research objective, and defined household waste classification according to the opinions of the General Office of the People's Government of Jiangsu Province on strengthening the work of municipal solid waste classification. The authenticity data clearly emphasized to avoid invalid questionnaires. The confidentiality of private information was ensured. All the data were used for scientific purposes only. In the second part, the scale for measuring the residents understanding towards household waste sorting was developed. All measurement items stated above were adopted (Table 1). A 7-point scale was designed, where 7 represented the strongest approval and 1 represented the strongest disapproval. The items selected from previous studies were translated into Chinese. Several professors and graduate students were invited to rewrite the Chinese sentences for easy reading and comprehension. In addition, the order of items were altered in the original scale to ensure data quality, because the respondents tend to choose similar answers when facing aggregate topics. In the third part, the respondents personal information were collected, including gender, age, education level, monthly income, and household size. Finally, the residents were appreciated for participating in the survey.

3.2. Sample and procedure

The primary data were collected through a questionnaire survey. The scale and questionnaire were designed as mentioned above. Field research was carried out to obtain authentic data. A multi-stage random sampling method was used to select residents in rural regions. According to the economic level and geographical location, towns, villages, and residents were similarly selected in Wuxi, Nanjing, and Lianyungang of Jiangsu Province. A total of 350 residents were chosen to participate in the research. The questionnaires with blank options or an answer time of less than 3 min were invalid. In all, 322 questionnaires were valid with an effective rate of 92%. The survey was conducted during the summer vacation (July 10th to September 1st, 2019), through Sojump, an online questionnaire website, and face-to-face interviews. The profile of the respondents is seen in Table 2. The demographic characteristics of the respondents are in line with the local population structure with respect to educational level, monthly income, and household size. However, the participant rate of women is higher and the average age of the respondents was older than that of the local population. The reason might be that women do more housework than men in rural areas, and young people are often out-migration for work in cities. Therefore, more elder female respondents were chosen for this study.

Potential non-response bias and common method bias were evaluated. Several T-tests were conducted to compare the early and late respondents. The participants were selected who responded in the first 7 days as the early respondents and the last 7 days as the late respondents. No significant differences were shown regarding age, gender, education, income, and household size. Thus, the non-response bias can be ignored. Harman's one-factor test was applied to test the common method bias which might threaten the validity of this study. All the items were divided into seven factors. The eigen values were higher than 1, and explained 70.6% of the total variances. The first factor explained only 32.3% of the variances, lower than the benchmark value of 50%, which showed that common method bias is not serious.

3.3. Statistical analysis

Usually, the structure equation model (SEM) is used to assess latent variables at the observation level and test relationships between latent variables at the theoretical level [57]. This study adopted the SEM to assess the hypotheses. Two types of SEM methods should be considered, namely, covariance-based techniques (CB-SEM) and variance-based partial least squares (PLS-SEM). CB-SEM validates or compares theories. PLS-SEM has more distinctive methodological features than CB-SEM, such as less stringent assumptions, small sample size, formative measurement of latent variables, and exploratory research and theory development. PLS-SEM was adopted as this study focused on the exploration of government policy, ecological value, and awareness of waste sorting necessity. A great deal of causal relationships were estimated in the conceptual model, and in this research, SU and PBC are formative measurements. Smart PLS 3.2.6. were used to analyze the questionnaire data and test the hypotheses.

Table 1
Constructs and measurement items

Construct	Items	Measurement items	Sources
Sorting attitude (SA)	SA_1	I think household waste recycling is useful to protect the environment.	Wang et al. [12]
	SA_2	Participation in household waste sorting is a wise action.	Ru et al. [21] Klöckner [52]
	SA_3	Everybody should share the responsibility of sorting household waste.	
Subject norm (SU)	SU1	Most people who are important to me would think I should engage in household waste sorting.	Francis et al. [55] Wang et al. [12]
	SU2	My colleague engages in household waste sorting.	
	SU3	I feel the social pressure to sort the household wastes in daily life.	
	SU4	I understand the relevant laws and regulations for household waste sorting.	
Perceived behavioral control (PBC)	PBC_1	My families have participated in recycling household waste.	Tonglet et al. [56]
	PBC_2	Sorting household waste is easy in my daily life.	Ru et al. [21]
	PBC_3	Whether or not conducting household waste sorting is completely up to me.	
Government policy (GOV)	GOV_1	Policy incentives can affect my household waste sorting behavior.	Xia [50]
	GOV_2	Sanctions can affect my household waste sorting behavior.	
	GOV_3	Training or publicity can affect my household waste sorting behavior.	Halvorsen [53]
Awareness of sorting necessity (AW)	AW_1	Improper disposal of household waste can cause a waste of resources.	Wang et al. [12]
	AW_2	Improper disposal of household waste can cause environmental pollution.	Laroche et al. [45]
	AW_3	Improper disposal of household waste can harm human health.	
Ecological value (EA)	EA_1	My children and I will enjoy a better environment through environmental protection.	Obeng and Aguilar [43] Sagie et al. [54]
	EA_2	My health will benefit from a better environment	Laroche et al. [45]
	EA_3	A clean environment offers me better ways of recreation.	
Sorting intention (SI)	SI_1	I intend to engage in household waste sorting in the future.	Wan et al. (2012)
	SI_2	I intend to sort household waste regularly if there are food waste collection measures.	Wang et al. [12]
	SI_3	I intend to tell surrounding people about my waste sorting experience.	

Table 2
Demographic characteristics of the respondents in Jiangsu Province, China (n = 322)

Demographic Variable		Number	Percentage
Gender	Male	124	38.4%
	Female	198	61.6%
Age	Under 20	22	6.8%
	20–30	34	10.6%
	31–40	83	25.8%
	41–50	118	36.6%
	51 and above	65	20.2%
Educational level	Below elementary school	19	5.8%
	Elementary school	67	20.8%
	Junior middle school	137	42.5%
	High school	80	24.7%
	Higher education	20	6.2%
Monthly income (RMB)	Less than 1000	32	9.9%
	1000–3000	140	43.6%
	3001–5000	73	22.8%
	5001–7000	51	15.8%
mo	More than 7000	25	7.9%
Household size (Person)	1–3	134	41.6%
	4–6	182	56.4%
	More than 7	6	2%

4. Data analysis and results

PLS-SEM analysis contains two steps, namely, measurement model analysis and structural model analysis [58]. The measurement model analyzes the relationships between constructs and the corresponding items. The structural model analyzed the relationships between these constructs. In the measurement model, PLS-SEM could estimate formative construct and reflective construct simultaneously, with weights explaining formative indicators and loadings for reflective indicators. In this study, SU and PBC of the modified TPB are set as formative indicators, which is different from previous studies. Take subjective norms for example, a person under strong social pressure would have higher subjective norms of behavior. As for the following data analysis, the measurement model was first evaluated to guarantee the reliability and validity of the constructs. Secondly, a structural model was applied to test the relationship among the hypothesized constructs.

4.1. Measurement model analysis

If the indicators are reflective, their reliability and validity should be thoroughly examined. Their outer loadings, composite reliability, AVE, and its square root should be reported. While if the indicators are formative, it is meaningless to report the conventional validity. When reliability becomes an irrelevant criterion for assessing formative measurement, the examination of validity becomes crucial. Confirmatory factor analysis (CFA) was adopted to estimate the model's reliability and validity. To confirm the reliability and validity of the model, confirmatory factor analysis (CFA) was adopted. Convergent validity and composite reliability estimated the correlation among the items with the constructs [59]. Cronbach's alpha (CA) and composite reliability (CR) are two traditional coefficients for assessing internal consistency reliability. As shown in Table 3, the values of CA ranged from 0.815 to 0.984, and the values of CR ranged from 0.887 to 0.956, which are all above the minimum recommended 0.7 value. The construct's reliability was confirmed. Indicator reliability describes the degree to which variables are consistent with what is intended to be measured, and the reflective indicators' loadings could be monitored to assess indicator reliability. The indicators' loadings ranged from 0.699 to 0.946, which were significant at the 0.05 level, and greater than the recommended threshold 0.7 value or 0.5 value [58,60].

The convergent validity and discriminant validity of the constructs were tested. Convergent validity, that is, the reflective level of individual items to a construct converges compared to items measuring different constructs. It was estimated by the average variance extracted (AVE) proposed by Fornell and Larcker [59]. The AVE scores of this study varied from 0.725 to 0.878, all larger than the recommended minimum value of 0.5. In other words, all the individual items in corresponding constructs showed strong convergent validity. Discriminant validity tested whether the measures of different constructs differ from one another. At

Table 3
Confirmatory factor analysis

Construct	Indicator	Standardized loading	Load weight	Cronbach's α	CR	AVE
Sorting attitude (SA)	SA_1	0.946***	–	0.930	0.956	0.878
	SA_2	0.939***	–			
	SA_3	0.926***	–			
Subject norm (SU)	SU_1	–	0.266***	–	–	–
	SU_2	–	0.794***			
	SU_3	–	0.219***			
	SU_4	–	0.746***			
Perceived behavioral control (PBC)	PBC_1	–	1.102***	–	–	–
	PBC_2	–	0.404***			
	PBC_3	–	0.554***			
Government policy (GOV)	GOV_1	0.842***	–	0.830	0.898	0.745
	GOV_2	0.918***	–			
	GOV_3	0.827***	–			
Awareness of sorting necessity (AW)	AW_1	0.922***	–	0.909	0.942	0.845
	AW_2	0.939***	–			
	AW_3	0.904***	–			
Ecological value (EV)	EV_1	0.942***	–	0.815	0.887	0.725
	EV_2	0.913***	–			
	EV_3	0.699***	–			
Sorting intention (SI)	SI_1	0.892***	–	0.984	0.934	0.825
	SI_2	0.945***	–			
	SI_3	0.887***	–			

Note: *P < 0.1, **P < 0.05, ***P < 0.01.

the same time, it mainly tests if these items unintentionally measure something else. As shown in Table 4, the square root values of AVE for each latent variable were all larger than the correlation between a pair of constructs. The results confirmed the discriminant validity.

As to the formative construct, the indicator validity and construct validity need to be assessed. The indicator weights varied between 0.266 and 1.102, above the minimum recommended value of 0.2. They were also all significant at the 0.05 level employing bootstrapping. The construct validity was assessed by discriminant validity. MacKenzie et al. [61] suggested to test the interconstruct correlations between formative constructs. Correlations between formative and all other constructs range from 0.211 to 0.403, less than 0.7, indicating sufficient discriminant validity.

4.2. Structure equation model

In order to unveil the relationships between the constructs, the structural equation model was adopted. The model was run by a bootstrap resampling procedure with 300 collected data points and 5,000 sub-samples. This bootstrap resampling randomly selected subsamples to evaluate the significance of the hypotheses [58]. The results are shown in Table 5 and Fig. 2. Different from CB-SEM, PLS-SEM does not provide statistical indicators for validating the theoretical models, such as χ^2, GFI, AGFI, and others. Coefficient of determination (R^2), goodness of fit (GoF), effect size (f^2), and path coefficients were the main assessing indicators in PLS-SEM. The R^2 values of 0.19, 0.33, and 0.67 can be regarded as weak, moderate, and solid respectively. Wetzels et al. [62] suggested a single criterion of GoF for PLS based on the average AVE and the average R^2, $\text{GoF} = \sqrt{\overline{\text{AVE}}\sqrt{R^2}}$, and the values 0.35, 0.50, and 0.61 are regarded as small, medium, and large respectively. f^2 measures if an independent construct has a substantial impact on a dependent construct, and could be tested by the following formula based on the R^2 value with the proposed construct included and excluded, $f^2 = \left(R^2_{\text{incl}} + R^2_{\text{excl}}\right) / \left(1 - R^2_{\text{incl}}\right)$. Values of 0.020, 0.150, and 0.350 indicate the predictor variable's low, medium, or large effect in the structural model.

- Model 1 tested the traditional TPB with three original variables, SA, SU, and PBC. The R^2 value was

Table 4
Descriptive statistics and correlation

Construct	Means	SD	AT	SU	PBC	GOV	AW	VA	IN
Sorting attitude (SA)	6.62	1.02	0.937						
Subject norm (SU)	4.17	1.86	0.400	–					
Perceived behavioral control (PBC)	4.60	1.61	0.398	0.326	–				
Government policy (GOV)	6.22	1.30	0.398	0.403	0.395	0.863			
Awareness of sorting necessity (AW)	6.54	0.89	0.688	0.278	0.211	0.533	0.919		
Ecological value (EV)	5.16	1.90	0.107	0.324	0.259	0.347	0.200	0.852	
Sorting intention (SI)	6.31	1.15	0.577	0.556	0.383	0.632	0.549	0.383	0.908

Note: Values in the diagonal row (bold) are the square roots of AVEs and the others are the correlations between constructs.

Table 5
Hypotheses testing results

Construct	Model 1	Model 2	Model 3	Model 4				
				SA	SU	EV	AW	SI
SA	0.386***	0.227**	0.22**					0.232**
SU	0.338**	0.291**	0.244					0.288**
PBC	0.199**	0.142*	0.065					0.151**
EV		0.184**	0.14**					0.177**
AW		0.249**	0.117					0.247**
GOV			0.335*	0.398***	0.403***	0.347***	0.533***	
R^2	0.482	0.554	0.621	0.158	0.162	0.121	0.284	0.551
GOF	0.631	0.676	0.716	0.372		0.214	0.49	0.674
f^2	0.158	0.061	0.069	0.188	0.194	0.137	0.397	0.061

Mediating effect	GOV→SA→SI	GOV→SU→SI	GOV→EV→SI	GOV→AW→SI
SOBEL Z TEST	17.1 Full mediation	17.3 Full mediation	18.1 Full mediation	20.2 Full mediation

Note: *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

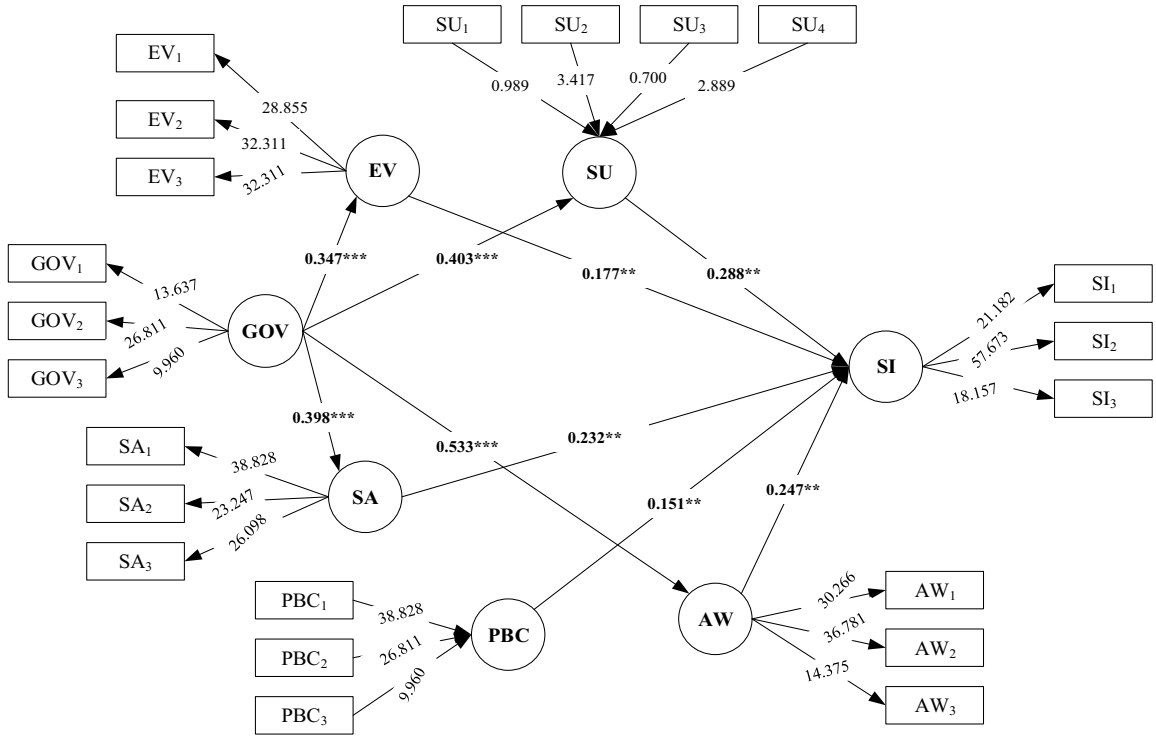

Fig. 2. Research framework of the household waste sorting intention of rural residents.

0.482, which accounted for 48.2% of the variance in SI, regarded as moderate. The GoF and f^2 values were 0.631, 0.158, considered to be large and medium respectively. All Path coefficients were significant at the level of 0.05.

- Model 2 included the additional variables of ecological value and awareness of waste sorting necessity based on Model 1. The paths of SA, SU, EA, and AW constructs were significant at the level of 0.05, and that of the PBC construct was significant at the level of 0.1. The R^2 value was 0.554, moderate, and could explain 55.4% of the variance in the SI. The GoF was 0.676 at the high level, and the f^2 was 0.061 at the small level.
- Model 3 included the additional variables of GOV based on Model 2, and could explain 62.1% of the variance in SI. The paths of SA, and EV constructs were significant at the level 0.05, and that of GOV was at the 0.1 level, but no significant effects were found on SU, PBC, and AW constructs. The R^2, GoF, and f^2 values were 0.621, 0.716, and 0.069, regarded as moderate, high, and low respectively.
- Model 4 had four influence paths from GOV to SI, and all path coefficients were significant at least at the level of 0.05. The R^2 value of the SI construct was 0.551, which was considered to be moderate, and could account for 55.1% of the variance in SI. The GoF and f^2 values of the SI construct were 0.674, and 0.061 being regarded as large and low respectively. Compared to Model 1-Model 4, Model 4 was deemed to be a generous fit.

As shown in Fig. 2, SA, SU, PBC, EV, and AW had a significantly positive influence on SI at the level of 0.05, with the regression coefficients varying from 0.151 to 0.288. Therefore, H_1, H_2, H_3, H_7 and H_8 were accepted. The effects of GOV on SA, SU, EV, and AW were significant and positive at the level of 0.01 with standardized regression coefficients ranging from 0.347 to 0.533. Thus, H_5, H_6, H_9, H_{10} were also accepted, whereas H_4 was rejected. Bootstrap was used for repeated sampling, and the sobel test was conducted according to the method of Weng et al. [63]. The Sobel test z values of SA, SU, EV, AW mediating the impact of GOV on SI ranged from 17.1 to 20.2, which was above 1.96, thus verifying their complete mediating effect. $H_{5\text{-}1}$, $H_{6\text{-}1}$, $H_{9\text{-}1}$, $H_{10\text{-}1}$ were also accepted.

5. Discussion and implications

TPB lays a good foundation for understanding the SI of rural residents. SU are the most decisive factors for SI, while SA and AW are the second and third important determinants during path adjustment. The findings are basically in line with the study by Ru et al. [21]. Wu et al. [64] also stated that environmental cognition and environmental attitude have positive impacts on household waste management behavior. The two additional constructs (EV and AW) were adopted in this study to strengthen the predictive power of TPB. The path coefficients of SU, PBC, and AW showed no more significance after adding GOV. Thus, GOV has no direct effect on SI, indicating the current government policies are not sufficient, and policy content or implementation process may not promote the SI of rural residents. The results support the findings of Wang et al. [12] who stated that information publicity also had no direct effect on e-waste recycling intention, and more recycling knowledge and channels should be injected into publicity.

SA, SU, and PBC have significant impacts on SI with the regression coefficients being 0.232, 0.288, and 0.151 respectively. SA is generally operationalized by requiring individuals to evaluate waste sorting behavior as to whether they are good, wise, enjoyable, or pleasant, among other descriptors. According to the measurement of SA, cultivating residents consciousness of environmental protection and guiding their sorting responsibility is very meaningful. These findings were also supported by Shi et al. [35], Wan et al. [22] and Knussen et al. [27]. As SU exerts great influence on SI, the attitude of surrounding people determines the enthusiasm of residents to participate in household waste sorting. In rural social groups, the acquaintance network is very close. The attitudes or behavior of neighbors and relatives can easily influence others' behavior around them. If SU plays an efficient role, rural residents will improve their SI greatly. PBC is mainly measured by both sorting experience and convenience. Residents who have waste sorting experience or feel that the government provides convenient waste sorting facilities are more willing to participate in further waste sorting action. Therefore, it is necessary to improve related infrastructure and waste sorting systems. On the basic theoretical framework, two determinants EV and AW are added. EV refers to the values that determine whether actions should be taken based on the costs or benefits to the ecosystem or biosphere, reflecting an individual's environmental inclination and being considered an important predictor of environmentally responsible behavior. EV has a significantly positive correlation with SI, and is remarkable throughout the variables adjustment process, denoting that sorting behavior is impressionable to EV. AW has a great positive effect on the SI of rural residents with a regression coefficient being 0.247. Environmental cognition is the starting point of environmental behavior formation, especially the cognition of environmental problems is much more relevant to various environmental behaviors.

GOV is measured by incentive, sanctions, and training or publicity in this study. GOV has a significant impact on SA, SU, EV, and AW at a 1% significance level. SA, SU, EV, and AW play complete mediating roles, indicating that the policy mechanism for waste classification has played its part. However, it is still inefficient and fails to play a directly adequate leading role. According to Xia et al. [50], in all types of environmental regulations, restrictive and incentive regulations could significantly enhance the rural resident's green production intention, while the effect of guiding regulations as governmental propaganda or technical support is not obvious. GOV has been found to influence environmental behavior through SU, and economic incentives, and these informal regulations have complementary effects to promote environmental protection especially [65,66]. The regression coefficients between GOV and SU, SU and IN are 0.403 and 0.288 being at much higher levels in the whole model in our study. SU determines the participating passion towards sorting behavior. If SU works, the SI of rural residents will be greatly improved. The regression coefficient between GOV and AW is the highest at 0.533. AW also plays a very decisive effect during behavioral formation in the model. Therefore, GOV, especially training and publicity such as community-based lectures, education or training, brochures or leaflets, and radio announcements, should be adopted. These GOVs, from which residents can gradually realize the drawbacks and environmental pollution of discarding or improperly handling household waste, help to stimulate residents to form positive environmental awareness and SA. Individuals' value is gradually formed under the effect of family and society, among which the influence of institutional norms is decisive. Therefore, EV is generally affected by administrative rules, people with different EVs tend to form different environmental attitudes. The path mediated by EVs plays a much lower role than others, showing that EVs should be promoted by perfect institutional systems and other means.

Several theoretical contributions have been made in this study. First, this study incorporated GOV, EV, and AW into TPB, which enriches TPB. The determinants as SU and PBC were measured by formative factors instead of reflective factors and the traditional measurement method of TPB is further optimized. Second, this study explored the effects of GOV, EV, and AW on SI within the framework of TPB, which confirmed the direct significance role of EV and AW, and the indirect significance role of GOV mediating by EV, AW, SA, and SU. Third, an empirical analysis with the modified TPB model mentioned above was carried out in the context of the Yangtze River Delta region of China. With the regional, institutional, and economic advantages of Jiangsu province in this region, the detecting of the SI of rural residents is representative and theoretically significant.

6. Conclusions and limitations

This study modified TPB with three additional variables, EV, AW, and GOV. SU and PBC were detected by formative constructs. The mediating effects of SU, EV, AT, and AW were also analyzed. Results show that EV and AW have a significantly positive effect on SI. SU has the greatest impact on the regression coefficient. GOV impacts SI indirectly through the mediating effect of SU, EV, AW, and AT. The paths mediated by SU and AW are much more important. Based on these findings, government regulation, subsidy, supervision, village collective awards, waste sorting skills competition with awards, etc., could be applied to encourage residents waste sorting enthusiasm. Punitive measures should also be used to supervise rural residents sorting behavior. In addition, the restraining power of informal systems such as village rules and folk contracts should be taken seriously. Rural residents have a strong herd mentality. Special management organizations should be set up at the village level to improve supervision and cultivate good life inertia of residents. Local government should strengthen waste sorting publicity and training to increase the residents' environmental awareness and full understanding of the benefits of waste sorting. Relevant departments also should increase the frequency of publicity dissemination. The propaganda content should include the knowledge and skill of waste sorting, the pollution caused by discarding waste, how to sort household waste correctly, and so on. The convenience of waste sorting is also an important determinant. Relevant departments should increase the investment in sorting facilities, and provide convenient sorting waste bags and bins for rural residents. Recyclers and transporters should collect the waste on time. Meanwhile,

waste sorting instructors could also help rural residents to identify waste types, and teach them correct sorting methods.

Although we conducted a comprehensive study, limitations of this study do exist. The following limitations must be recognized and addressed in future research. First, this study only relied on self-reports. Thus, it is inevitable that participants may overestimate their sorting intention to meet social expectations. Second, this study was implemented through the combination of online and offline surveys in rural areas of Jiangsu Province. Bias may exist in sample representation. Third, the modified TPB model was a detected redundancy model with reflective indicators and formative indicators. Future research should test and verify the current research findings and redundancy model applicability by replicating the analysis on a large and more representative sample. Finally, this study only addressed general household waste sorting intention. The mechanisms of sorting intention of rural residents may vary with characteristics of demographic variables. Thus, future studies can include variables such as gender, age, education, and so forth to compare sorting behavioral mechanisms in different groups.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

It is declared by the authors that this article is free of conflict of interest.

Funding

This study was funded by the General Project of Humanity and Social Science of the Ministry of Education in China (No. 18YJCZH172), 2020 Annual Chinese Postdoctoral Science Foundation (No. 2020M671528), and 2020 Annual Jiangsu Postdoctoral Research Funding Project (No. 2020Z001), and Universities' Philosophy and Social Science Project in Jiangsu Province (No. 2017SJB0147), and 2020 Annual Jiangsu Productivity Society Project (No. JSSCL2019A010). The authors would like to express their gratitude to the survey respondents for their particle answers and the anonymous reviewers for their valuable comments.

References

[1] C. Mbande, Appropriate approach in measuring waste generation, composition and density in developing areas, J. S. Afr. Inst. Civ. Eng, 45 (2003) 2–10.
[2] A. Mahar, R.N. Malik, A. Qadir, T. Ahmed, Z. Khan, M. Laeeq Khan, Review and analysis of current solid waste management situation in urban areas of Pakistan, Proceedings of the International Conference on Sustainable Solid Waste Management, Citeseer, 8 (2007) 36.
[3] H.J. Wen, Research on rural household garbage treatment and operation mechanism of "cooperative" mode, Rural Economy and Science-Technology, 28 (2017) 1–2.
[4] Y.C. Moh, L. Abd Manaf, Overview of household solid waste recycling policy status and challenges in Malaysia, Resour. Conserv. Recycl., 82 (2014) 50–61.
[5] D. Hoornweg, P. Bhada-Tata, What a waste: a global review of solid waste management, World Bank Working Paper 68135, 2012.
[6] M. Pothitou, R.F. Hanna, K.J. Chalvatzis, Environmental knowledge, pro-environmental behaviour and energy savings in households: an empirical study, Appl. Energy, 184 (2016) 1217–1229.
[7] W.A.W.A.K. Ghani, I.F. Rusli, D.R.A. Biak, A. Idris, An application of the theory of planned behaviour to study the influencing factors of participation in source separation of food waste, Waste Manage., 33 (2013) 1276–1281.
[8] K. Schmidt, E. Matthies, Where to start fighting the food waste problem? Identifying most promising entry points for intervention programs to reduce household food waste and overconsumption of food, Resour. Conserv. Recycl., 139 (2018) 1–14.
[9] A.P. Bortoleto, K.H. Kurisu, K. Hanaki, Model development for household waste prevention behaviour, Waste Manage., 32 (2012) 2195–2207.
[10] A.H. Pakpour, I.M. Zeidi, M.M. Emamjomeh, S. Asefzadeh, H. Pearson, Household waste behaviours among a community sample in Iran: an application of the theory of planned behaviour, Waste Manage., 34 (2014) 980–986.
[11] T. Ramayah, J.W.C. Lee, S. Lim, Sustaining the environment through recycling: an empirical study, J. Environ. Manage, 102 (2012) 141–147.
[12] Z. Wang, D. Guo, X. Wang, B. Zhang, B. Wang, How does information publicity influence residents' behaviour intentions around e-waste recycling?, Resour. Conserv. Recycl., 133 (2018) 1–9.
[13] A. Varotto, A. Spagnolli, Psychological strategies to promote household recycling. A systematic review with meta-analysis of validated field interventions, J. Environ. Psychol., 51 (2017) 168–188.
[14] R.A. Begum, C. Siwar, J.J. Pereira, A.H. Jaafar, Attitude and behavioral factors in waste management in the construction industry of Malaysia, Resour. Conserv. Recycl., 53 (2009) 321–328.
[15] S. Wadehra, A. Mishra, Encouraging urban households to segregate the waste they generate: insights from a field experiment in Delhi, India, Resour. Conserv. Recycl., 134 (2018) 239–247.
[16] Q. Li, R. Long, H. Chen, Empirical study of the willingness of consumers to purchase low-carbon products by considering carbon labels: a case study, J. Cleaner Prod., 161 (2017) 1237–1250.
[17] L.W. Hiselius, L.S. Rosqvist, Mobility Management campaigns as part of the transition towards changing social norms on sustainable travel behavior, J. Cleaner Prod., 123 (2016) 34–41.
[18] I. Ajzen, The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50 (1991) 179–211.
[19] C.J. Armitage, M. Conner. Efficacy of the theory of planned behaviour: a meta-analytic review, Br. J. Social Psychol., 40 (2001) 471–499.
[20] S. Wang, J. Fan, D. Zhao, S. Yang, Y. Fu, Predicting consumers' intention to adopt hybrid electric vehicles: using an extended version of the theory of planned behavior model, Transportation, 43 (2016) 123–143.
[21] X. Ru, S. Wang, Q. Chen, S. Yan, Exploring the interaction effects of norms and attitudes on green travel intention: an empirical study in eastern China, J. Cleaner Prod., 197 (2018) 1317–1327.
[22] C. Wan, G.Q. Shen, S. Choi, Experiential and instrumental attitudes: interaction effect of attitude and subjective norm on recycling intention, J. Environ. Psychol., 50 (2017) 69–79.
[23] A. De Leeuw, P. Valois, I. Ajzen, P. Schmidt, Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: implications for educational interventions, J. Environ. Psychol., 42 (2015) 128–138.
[24] P.C. Stern, Managing scarce environmental resources, Handb. Environ. Psychol., 2 (1987) 1043–1088.
[25] K.Y.H. Connell, Internal and external barriers to eco-conscious apparel acquisition, Int. J. Consum. Stud., 34 (2010) 279–286.

[26] G.A. Guagnano, P.C. Stern, T. Dietz, Influences on attitude-behavior relationships: a natural experiment with curbside recycling, Environ. Behav., 27 (1995) 699–718.
[27] C. Knussen, F. Yule, J. MacKenzie, M. Wells, An analysis of intentions to recycle household waste: the roles of past behaviour, perceived habit, and perceived lack of facilities, J. Environ. Psychol., 24 (2004) 237–246.
[28] S.Y. Chen, Using the sustainable modified TAM and TPB to analyze the effects of perceived green value on loyalty to a public bike system, Transp. Res. Part A Policy Pract., 88 (2016) 58–72.
[29] F. Echegaray, F.V. Hansstein, Assessing the intention-behavior gap in electronic waste recycling: the case of Brazil, J. Cleaner Prod., 142 (2017) 180–190.
[30] C. Wan, R. Cheung, G. Qiping Shen, Recycling attitude and behaviour in university campus: a case study in Hong Kong, Facilities, 30 (2012) 630–646.
[31] H. Best, T. Kneip, The impact of attitudes and behavioral costs on environmental behavior: a natural experiment on household waste recycling, Social Sci. Res., 40 (2011) 917–930.
[32] V. Blok, R. Wesselink, O. Studynka, R. Kemp, Encouraging sustainability in the workplace: a survey on the pro-environmental behaviour of university employees, J. Cleaner Prod., 106 (2015) 55–67.
[33] M. Yazdanpanah, M. Forouzani, Application of the theory of planned behaviour to predict iranian students' intention to purchase organic food, J. Cleaner Prod., 107 (2015) 342–352.
[34] M. Greaves, L.D. Zibarras, C. Stride, Using the theory of planned behavior to explore environmental behavioral intentions in the workplace, J. Environ. Psychol., 34 (2013) 109–120.
[35] H. Shi, S. Wang, D. Zhao, Exploring urban resident's vehicular PM2.5 reduction behavior intention: an application of the extended theory of planned behavior, J. Cleaner Prod., 147 (2017) 603–613.
[36] S. Lizin, M. Van Dael, S. Van Passel, Battery pack recycling: behaviour change interventions derived from an integrative theory of planned behaviour study, Resour. Conserv. Recycl., 122 (2017) 66–82.
[37] S.P. Lu, X.Q. Li, Z.H. Du, The models and evolution path of rural household waste governance, J. East. China Univ. Technol., 37 (2018) 14–154.
[38] K. Lim-Wavde, R.J. Kauffman, G.S. Dawson, Household informedness and policy analytics for the collection and recycling of household hazardous waste in California, Resour. Conserv. Recycl., 120 (2017) 88–107.
[39] R.E. Rhodes, M.R. Beauchamp, M. Conner, G.-J. deBruijn, A. Latimer-Cheung, N. Kaushal, Are mere instructions enough? Evaluation of four types of messaging on community depot recycling, Resour. Conserv. Recycl, 90 (2014) 1–8.
[40] J.M. Wang, A.Z. He, Psychological attribution and policy paths of consumer's low carbon consumption behavior: an exploratory research based on grounded theory, Nankai Business Review, 14 (2011) 80–89+99.
[41] S.H. Schwartz, Are there universal aspects in the structure and contents of human values?, J. Social Issues, 50 (1994) 19–45.
[42] J.I.M. De Groot, L. Steg, Value orientations and environmental beliefs in five countries: validity of an instrument to measure egoistic, altruistic and biospheric value orientations, J. Cross-Cultural Psychol., 38 (2007) 318–332.
[43] E.A. Obeng, F.X. Aguilar, Value orientation and payment for ecosystem services: perceived detrimental consequences lead to willingness-to-pay for ecosystem services, J. Environ. Manage., 206 (2018) 458–471.
[44] G.M. Wang, J.X. Li, S.X. Liao, An empirical analysis of the relationship between personal values, environmental attitude and consumers green purchasing behavior, Soft Sci., 24 (2010) 135–140.
[45] M. Laroche, J. Bergeron, G. Barbaro-Forleo, Targeting consumers who are willing to pay more for environmentally friendly products, J. Consum. Mark., 18 (2001) 503–520.
[46] Y. Dhokhikah, Y. Trihadiningrum, S. Sunaryo, Community participation in household solid waste reduction in Surabaya, Indonesia, Resour. Conser. Recycl., 102 (2015) 153–162.
[47] S. Bhawal Mukherji, M. Sekiyama, T. Mino, B. Chaturvedi, Resident knowledge and willingness to engage in waste management in Delhi, India, Sustainability, 8 (2016) 1065.
[48] Z. Han, D. Zeng, Q. Li, C. Cheng, G. Shi, Z. Mou, Public willingness to pay and participate in domestic waste management in rural areas of China, Resour. Conser. Recycl., 140 (2019) 166–174.
[49] Q.C. Gao, Changing bad habits through the village regulations: a case study of Shiyin village, Pingqiu Town, Jinping County, Guizhou Province, China, Law Sci. Mag., 39 (2018) 78–85.
[50] J.Q. Xia, K. He, J.B. Zhang, Effect of environmental regulations and village regulations on farmers' green production willingness: taking the resource use of livestock and poultry waste of large-scale pig farmers as an example, Chin. J. Eco. Agric., 27 (2019) 1925–1936.
[51] L.J. Guo, Z.Y. Huang, H.G. Chou, Study on the dynamic mechanism of pro-environment behavior in house garbage disposal——taking 1028 farmers in Jiangsu Province as an example, J. Shanxi Agric. Univ. (Social Science Edition), 17 (2018) 34–41.
[52] C.A. Klöckner, A comprehensive model of the psychology of environmental behaviour——a meta-analysis, Global Environ. Change, 23 (2013) 1028–1038.
[53] B. Halvorsen, Effects of norms and policy incentives on household recycling: an international comparison. Resources, Conservation and Recycling, 67 (2012) 18–26.
[54] A. Sagie, J. Kantor, D. Elizur, M.I. Barhoum, A cross-cultural investigation of personal values: the Israeli-Palestinian case, Probl. Perspect. Manage., 3 (2005) 148–157.
[55] J. Francis, M.P. Eccles, M. Johnston, A.E. Walker, J.M. Grimshaw, R. Foy, E.F.S. Kaner, L. Smith, D. Bonetti, Constructing questionnaires based on the theory of planned behaviour: a manual for health services researchers, Newcastle upon Tyne, UK: Centre for Health Services Research, University of Newcastle upon Tyne, 2004. http://openaccess.city.ac.uk/id/eprint/1735
[56] M. Tonglet, P.S. Phillips, A.D. Read, Using the theory of planned behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK, Resour. Conserv. Recycl., 41 (2004) 191–214.
[57] K.A. Bollen, Measurement models: The relation between latent and observed variables, Structural Equations with Latent Variables, (1989) 179–225.
[58] W.W. Chin, The partial least squares approach to structural equation modelling, Mod. Methods Bus. Res., 295 (1998) 295–336.
[59] C. Fornell, D.F. Larcker, Evaluating structural equation models with unobservable variables and measurement error, J. Mark. Res., 18 (1981) 39–50.
[60] D.W. Straub, Validating instruments in MIS research, MIS Quarterly, 13 (1989) 147–169.
[61] S.B. MacKenzie, P.M. Podsakoff, C.B. Jarvis, The problem of measurement model misspecification in behavioral and organizational research and some recommended solutions, J. Appl. Psychol., 90 (2005) 710.
[62] M. Wetzels, G. Odekerken-Schröder, C. Van Oppen, Using PLS path modeling for assessing hierarchical construct models: guidelines and empirical illustration. MIS Quarterly, 33 (2009) 177–195.
[63] Z.L. Weng, B.J. Ye, Analyses of mediating effects: the development of methods and models, Adv. Psychol. Sci., 22 (2014) 731–745.
[64] D.L. Wu, X.K. Zhao, B.L. Shi, et al. Influencing factors and mechanisms of environment behavior for rural residents participating in garbage governance, Ecol. Econ., 36 (2020) 191–197.
[65] Z.H. Ding, Y.L. Jiang, Y.W. Wang, How community environment matter in residents' intention of green consuming behavior, J. China Univ. Min. Technol., 23 (2021) 107–120.
[66] C.L. Li, Q. Zhang, H. Zhou, Social norms, economic incentives and farmers' recycling behavior of pesticide packaging waste, J. Nanjing Agric. Univ., 21 (2021) 133–142.