ISSN 2709-9210
Journal of Service, Innovation and Sustainable Development
Vol. 3 (2022) No. 1, pp. 95-106
DOI:10.33168/SISD.2022.0108

Moderating Effects of Supporting Factors on the Correlation between Residents' Environmental Intentions and Pro-environmental Behaviors

Hongli Mu, Shuang Zhang, Tongxin Sun

Beijing Union University, Beijing, 100026, China
hgtzhangshuang@buu.edu.cn

Abstract. Waste classification is a kind of pro-environmental behaviors in the residents private sphere. In order to promote waste classification, Beijing, Shanghai, Guangzhou and other cities have set up smart waste bins in their communities. In this paper, an attitude-intention-behavior model of residents' waste classification was constructed, and the moderating effect of supporting factors on residents' use of smart waste bins was studied. The results of the study show that a high level of support can effectively promote the development of residents' waste classification from intention to behavior, in which the specific measures include optimizing the hardware conditions for classification facilities of community waste and guidance of residents to learn methods how to do operation in an intelligent waste classification etc..

Keywords: Pro-environmental behaviors, waste classification, supporting factors, moderating effect.

1. Introduction

Pro environmental behaviors refer to the behaviors of minimizing the negative impact on the ecological environment or improving the ecological environment adopted by people in production and life in order to promote the sustainable development of economy and environment (Kollmuss and Agyman, 2002). From the field of pro-environmental behaviors, it can be divided into pro-environmental behaviors in the private domain and the public domain (Liao et al., 2020). Pro-environmental behaviors in the public domain mainly include participating in environmental public welfare organizations and paying attention to environmental quality. Pro-environmental behaviors in the private sphere mainly include waste classification, saving water and electricity, and purchasing environmentally friendly products. Pro-environmental behaviors in the private domain occur in people's daily life, and is actually a choice of attitude towards life. For most people, they will participate in environmental protection public welfare activities and contribute to environmental protection only if they are environmentally friendly in their daily life, such as classification waste. Therefore, it is of great practical significance to study pro-environmental behaviors in the private sphere.

In recent years, with the improvement of people's living standards and changes in lifestyles, the amount of domestic waste generated continues to increase. Statistics show that at present, the amount of waste generated per capita in China's cities reaches 1.0-1.2 kg per day. The massive accumulation of domestic waste has brought serious environmental pressure. The key to solving the problem of domestic waste accumulation is the recycling of waste. To achieve waste recycling, it is necessary to require the residents to conduct waste classification. In May 2021, the National Development and Reform Commission issued the "14th Five-Year Plan for the Development of Urban Domestic Waste Classification and Treatment Facilities", which proposed that by the end of 2025, the national urban domestic waste recycling rate should reach about 60%. To achieve this goal, the classification of domestic waste conducted by urban and rural residents must be vigorously promoted. Therefore, in a long period of time, waste classification will be an extremely important pro-environmental behavior in the lives of urban and rural residents in China.

Intelligent facilities have entered the field of public services during these years. Some cities are starting to promote smart waste bin in their communities. Smart waste bin is a facility that integrates the Internet of Things and uses card swiping, QR code scanning, mobile phone number verification, face recognition and other methods to open various waste delivery ports. It can calculate the amount of waste and convert it to points. The points can be exchanged for gifts or cash on the corresponding APP or applet. In order to better promote the use of smart waste bins in the community, it is necessary to study the impact mechanism of smart waste bin on residents' pro-environmental behaviors, and based on this, formulate corresponding guiding policies.

There are two hotspots in the current research on pro- environmental behaviors.

The first is the influence of psychological factors such as attitude, motivation, norms, concepts and perceptions on pro-environmental behavior. This part of research is mostly based on the theory of planned behavior, rational behavior, theoretical technology acceptance model and other research, psychological factors on the impact of a specific pro-environmental behavior. For example, Gao (2018) used the theory of planned behavior as a research framework to analyze the influence of environmental attitudes on consumers' green perceived value through subjective norms. For another example, based on the theory of planned behavior, Sheng et al. (2019) added two antecedent variables, ecological values and personal perception correlation, to explore the influence mechanism of consumers' green purchase intention. Second, the influence of Situational factors on pro-environmental behavior is studied. Some scholars have found in their studies that sometimes there is a deviation between environmental attitudes and pro-environmental behaviors, which leads to the problem of inconsistency between knowledge and practice. In order to explore the reasons for this problem, Situational factors have begun to be included in the scope of pro-environmental behavior research. Situational factors mainly include infrastructure, personal abilities, external conditions and so on. For example, Wang et al. (2019) studied the low-carbon commuting behavior of Xi'an citizens and found that environmental knowledge was one of the factors affecting citizens' low-carbon commuting, but it was affected by two moderating variables of housing area and distance between work and home. Weihong Huang (2016) studied the influence of farmers' environmental awareness on pro-environmental behavior in four counties, Fengdu, Wulong, Rongchang, and Tongnan, and the results showed that environmental public services had a significant positive moderating effect on the influence of farmers' environmental awareness on environmental behavior. Most of the existing results on pro-environmental behavior have been analyzed from psychological and situational factors. In recent years, intelligent facilities have increasingly entered the field of public services and started to influence people's psychology, which in turn affects their behavior. There are relatively few studies in this area. This paper will start from the influence of intelligence on residents' pro-environmental behavior and study how to promote the transformation of residents' pro-environmental intention to behavior.

In recent years, with the improvement of people's living standards and the change of life style, the amount of domestic waste production has been rising, and a large number of garbage has been accumulated. The massive accumulation of garbage has brought serious environmental pressure, and in some countries or regions, the phenomenon of garbage siege has appeared to varying degrees. The long-term accumulation of garbage has brought serious consequences of groundwater, ocean and soil pollution. According to data, more than 8 million tons of plastic enter the ocean every year, a large part of which is ingested by birds and fish, and even plastic waste components are found in microorganisms on the sea floor. In June 2017, UN

Secretary-General Guterres pointed out in his keynote speech after the opening of the Ocean Conference that according to a recent study, the total weight of plastic waste in the ocean may exceed that of fish by 2050 (Anonymous, 2017). Lasky, the chief expert of the United Nations Environment Programme (UNEP), pointed out that garbage is a misplaced resource and the only growing and inexhaustible resource on the earth. The results of a study by U.S. environmental expert Nebel show that 90% of domestic waste can be recycled (Bilianfu, 2020). Metals, plastics, glass, paper and so on in domestic waste can be reused through comprehensive treatment. Kitchen waste can be treated by biotechnology and turned into fertilizer. The classification of different types and attributes of garbage is the prerequisite for the realization of garbage recycling, and the classification of residents is a low-cost and efficient means of waste classification. In May 2021, the National Development and Reform Commission issued the 14th Five-Year Plan for the Development of Municipal Solid Waste Classification and Treatment Facilities, which mentioned that by the end of 2025, the utilization rate of municipal solid waste resources in China will reach about 60%. To achieve this goal, it is necessary to vigorously promote the classification of municipal solid waste among urban and rural residents. Therefore, in a long period of time, waste classification will be an extremely important pro-environmental behavior in the private sphere in the lives of urban and rural residents in China.

In recent years, intelligent equipment has entered the field of public services. Some cities began to promote smart waste bins in the community. Smart waste bin is a kind of intelligent equipment using the Internet of Things technology to classify domestic garbage. The use of smart waste bins is divided into three steps. The first step, residents open the corresponding garbage drop-off port by swiping the card, scanning the code or face recognition to classify and put into the dustbin. The second step, the garbage is weighed in the smart bin and converted into points. In the third step, residents can exchange daily necessities according to the number of points found on the corresponding APP. In order to promote the classification of residents' garbage, Beijing has set up smart waste bins in many communities. This research group investigated the use of smart waste bins in 20 communities in Beijing for two consecutive years in 2020 and 2021, and found that it is very common for smart waste bins to be abandoned and not used. Therefore, there is an urgent need to formulate targeted guidance policies. Scientific and reasonable policies should be based on mastering the mechanism of intelligent devices affecting residents' behavior. At present, there are a few of researches on this field in the academic field, with only a few of them focusing on the commercial field, such as the influence of banks, ATM machines on depositors' deposit and withdrawal behavior. There is little research on the impact of intelligent equipment on human behavior in the field of public services. The purpose of this study is to explore the influence mechanism of intellectualization on waste classification behavior of Beijing residents, and to explore the factors affecting the effect of usage, and on this basis, some suggestions were put forward to

optimize the relevant regulations, which provided a theoretical basis for the optimization of waste classification management policy in Beijing.

2. Theoretical model

2.1. Technology Acceptance Model

In the 1980s, American scholar Davis proposed the Technology Acceptance Model (TAM). This model is used to reflect the influence path and mechanism of information technology on user behavior. The user's perception of the usefulness and user friendliness of an information technology has a significant impact on the user's decision to use the information technology. The basic framework of the technology acceptance model is as follows: when users begin to use an information technology, external variables will affect users' perceived usefulness and perceived ease of use, which in turn affects attitudes and usage intentions, and ultimately influences usage behavior (Davis, 1989). After the technology acceptance model was put forward, some scholars have confirmed in the research on network platforms, WeChat public accounts, and online education that the model has a high explanatory power for users' behaviors of adopting information technology. (Xueqi Xu, 2020; Mengyin Li 2019).

Based on the Technology Acceptance Model, this study plans to construct a model of residents' behavior of using smart devices for waste classification. At present, there are few studies on the use of intelligent facilities in the field of public services, and there is a lacking of relevant references. Therefore, this study adopts a simplified model, which is using attitudes affects using intention, and then affects using behaviors.

2.2. 2.2 Basic assumptions

(1) Usage attitude

The determination of residents' attitude towards the use of smart waste bins mainly starts from two dimensions. First, perceived usefulness, which means the degree to which residents recognize the significance of waste classification. Generally speaking, the higher the residents' recognition of the importance of waste classification, the more they are willing to spend time and energy on separation. Second, perceived ease of use, which means residents' recognition of their ability to use smart waste bins. In general, if residents think they have the ability to use the smart waste bins, the more willing they are to use the smart waste bins. This paper argues that residents' recognition of the importance of waste classification and their recognition of their ability to use smart waste bins positively affect their intention to use smart waste bins.

(2) Intention of use

The determination of residents' intention to use the smart waste bins is based on two dimensions. First,target intention, which means the result intention of waste classification, such as active waste classification, recommending others to use smart

waste bins. Second, the execution intention which make efforts in waste classification, such as overcoming the difficulties in waste classification, willing to spend time etc. This paper concludes that intention to use positively influences residents' behavior of using smart waste bins.

(3) Usage behavior

The measurement of residents' behavior of using smart waste bins starts from two dimensions. First, residents' evaluation of their behaviors of using smart waste bins, whether residents are willing to use smart waste bins or not. Second, residents' evaluation of their own waste classification behaviors, whether residents are willing to continuously separate waste and whether they are willing to promote waste classification to their friends and relatives.

(4) Support factors

Residents are influenced by support factors when using the smart waste classification devices. The determination of support factors starts from two dimensions. First, the support from outside world, which mean the outside provides help for residents to use smart waste bin. This includes optimizing the conditions of use of the smart waste bins and improving the location and convenience of use. Second, resident's own support, that is their own ability to use the smart waste bins. Mainly refers to the residents themselves have the hardware and software conditions for the use of smart devices. In general, the residents' ability to use smart devices can be improved by outside help. This paper argues that the support factor has a moderating effect on the relationship between attitude and intention, and the relationship between intention and behavior.

In summary, this paper proposes the following assumptions.

H1: Residents' attitude towards using smart waste bins has a significant positive effect on their using intention.

H2: Residents' intention to use smart waste bins has a significant positive impact on using behaviors.

H3: Supporting factors positively moderate the relationship between using attitude and using intention.

H4: Supporting factors positively moderate the relationship between using intention and using behaviors.

3. Study Design and Data Testing

3.1. Questionnaire Design

Based on the technology acceptance model, a questionnaire was designed based on the research results of Ma Yiying (2020), Wang Zhiwei (2020) and other scholars. In the questionnaire, the four latent variables of using attitude (code T), using intention (code Y), using behaviors (code W), and support factor (code Z) each include three

to four observation variables. All items in the questionnaire were scored on a five-point Likert scale. When the respondents choose the options of strongly disagree, disagree, uncertain, agree, and strongly agree, it will be scale to 1, 2, 3, 4, and 5 points.

3.2. Sample inspection

The survey adopts the questionnaire survey method, and the survey objects are the citizens of Beijing who have used the smart waste bin. In March 2021, the research group commissioned a professional survey company to distribute questionnaires, and a total of 262 valid questionnaires were recovered. The research group conducted a population descriptive statistical analysis on the sample. In terms of gender: males accounted for 58.02%, females accounted for 41.98%; in terms of age distribution, 0.38% were under 12 years old, 16.03% were between 13 and 22 years old, 82.82 % were between 23 and 60 years old, and 0.77 % were over 61 years old. From the perspective of occupational distribution: students account for 14.12%, enterprise employees account for 53.43%, government or public institution employees account for 20.23%, individual industrial and commercial workers account for 10.69%, and retirees account for 1.53%. From the distribution of educational background: 11.07% are high school/technical secondary school and below, 80.53% are undergraduate/junior college students, and 8.4% are master's degree or above.

The reliability and validity of the survey were tested in this study, and the results are shown in Table 1. The test results showed that the Cronbach's a coefficient of using intention, using behaviors and supporting factors was between 0.7 and 0.8, and the Cronbach's a coefficient of using attitude was close to 0.7, which indicated that the reliability of the questionnaire was good. The combined reliability of each variable was greater than 0.7, and the average variance extraction was greater than 0.5, which indicated that the construct validity of the study was good.

Table 1: Questionnaire reliability and validity test

variable code	**T (using attitude)**	**X (using intention)**	**W (using behaviors)**	**Z (supporting factor)**
variable number of items	3	3	4	3
cronbach's a coefficient	0.761	0.815	0.806	0.780
kmo inspection	0.691	0.718	0.794	0.700
combined reliability	0.759	0.815	0.822	0.872
Average extracted variance value	0.515	0.595	0.537	0.694

4. Structural equation model analysis

4.1. Model Path Analysis

According to the previous theoretical model, we use the maximum likelihood method to test the fit of the model, and the relationship between the variables is shown in

Figure 1. The value of the model fit index conforms to the standard, which indicates that the model has good stability and can be used to analyze the pro-environmental behaviors of residents. The path coefficient of the model test is shown in Table 2. The attitude of use positively affects the using intention, and the using intention positively affects the using behaviors. Therefore, it is assumed that both H1 and H2 hold.

Table 2: Structural Equation Path Coefficients

Path	path coefficient	s.e	c.r	significance level	hypothesis verification
using attitude → using intention	0.921	0.122	9.798	***	H1 holds
using intention→ using behaviors	0.916	0.098	9.848	***	H2 holds

Note: *** represents P<0.001; S.E is the standard error of the estimated parameter; CR is the test statistic.

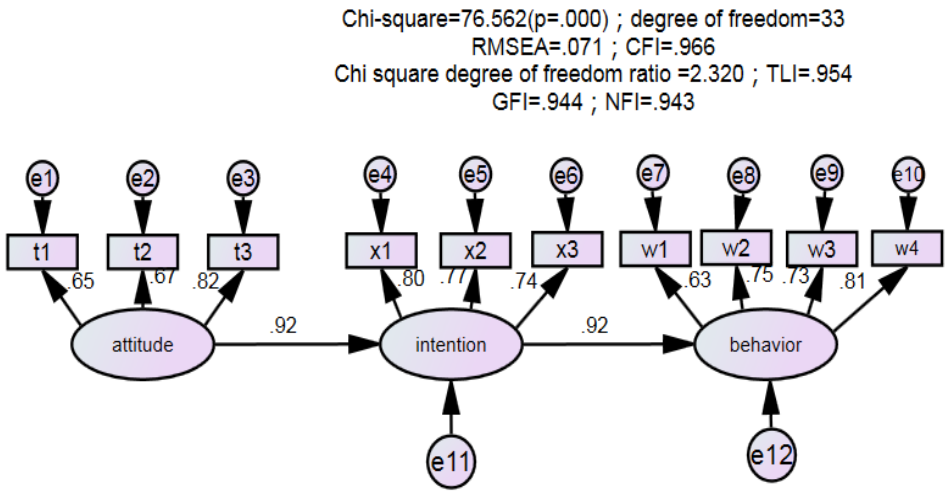

Fig. 1: The path diagram and standardized estimates

4.2. Analysis of Moderating Effects

Scholars ' research results show that support factors have a significant impact on residents' pro-environmental behaviors (Liao Maolin, 2020). Supporting factors include help from the outside, such as the installation of clearly marked and convenient waste classification bins in some residential areas. Supporting factors also come from the residents themselves. For example, when residents use smart waste bin, they need to use smartphones with code scanning capabilities. In order to study the difference in the influence of different levels of support factors on residents' waste classification behaviors, this paper deals with the sample data. First, calculate the mean of the supporting factors for each sample . Secondly, the samples with more than 80% scores are formed into the high support group , and the samples with lower

than 80% scores are formed into the low support group . Finally, the multi-group analysis method of amos software was used to compare the path coefficients and moderating effects of the two groups. The results are shown in Table 3.

Table 3: Moderating effect test of supporting factors

moderator	**path**		
	using attitude→using intention	**using intention → using behaviors**	
high support group	0.93 ***	0.82 ***	
low support group	0.80 ***	0.78 **	
significant difference	no	yes	
hypothesis verification	H3 does not hold	H4 holds	

(1) Table 3 shows that the moderating effect of supporting factors on the using attitude→using intention path regulation effect is not significant, and hypothesis H3 does not hold. This shows that there is no significant difference between the residents of the high support group and the low support group in the influence of using attitude on using intention. This is because the attitudes and intention of residents are mainly influenced by publicity and education.

(2) Table 3 shows that the moderating effect of supporting factors on the using intention→using behaviors path regulation effect is significant, and the hypothesis H4 holds. This indicates that the using intention of residents in the high support group has a greater impact on the using behaviors. This is because when residents place waste, the level of support directly affects whether the residents' waste classification behaviors can be successfully completed. In some circumstances, residents with a sense of waste classification are unable to implement classification behaviors due to the lack of supporting factors.

5. Research Conclusions and Implications

5.1. Research conclusions

(1) Based on the technology acceptance model and the previous literature, this paper constructs an attitude-intention-behavior model of residents' waste classification, which shows that residents' attitude has a significant positive impact on their use intention, and their use intention has a significant positive impact on their use behavior.

(2) This paper studies the moderating effect of support factors on residents' pro-environmental behavior by using the attitude - intention - behavior model of residents' waste classification and the multi-group analysis method of amos software. The results show that the moderating effect of support level on the path of attitude and intention is not significant, while the moderating effect of support level on the path of intention and behavior is significant. A high level of support can effectively

promote the development of waste classification intention to behaviors. Therefore, it is of great significance to improve the support level of waste classification.

5.2. Policy Implications

(1)To continuously publicize the significance of waste classification among residents. Knowledge is an important factor that influences attitude formation. A resident who knows about waste pollution is more likely to form an attitude of supporting waste classification. It is necessary to publicize and popularize the knowledge and methods of waste classification in various forms.

(2) To improve the support level of waste classification from the outside world. In 2020, the Beijing Municipal Bureau of Statistics conducted a survey on the classification of household garbage in Xicheng District of Beijing. The survey results show that the scientific setting of garbage bins affects the participation of residents in waste classification. The setting of smart waste bins should consider many aspects, such as the location of placement, the height of the bins and the height of the drop-off opening. In order to enhance the enthusiasm of residents for waste classification, it is necessary to study the location and convenience of smart waste bins, to form a scientific and reasonable hardware configuration scheme of smart waste bins, and to promote it in various communities.

(3) To enhance the level of support from residents themselves for waste classification. When residents use smart waste bins, the first step is to open the bins by scanning the code with smartphones. In the survey of some residential areas, the research group found that some elderly people could not classify and put in smart waste bins smoothly because they did not master the use methods. Therefore, it is necessary to take some measures to improve the residents' own level of support for waste classification. Firstly, the steps of using the smart waste bin are printed into simple and easy-to-understand propaganda pages with pictures and texts, which are preached in the community. For the convenience of the elderly with poor eyesight, audio explanation equipment can be installed on the intelligent dustbin, and the use steps can be explained by audio. Through these measures, residents of all ages and educational levels can master the use steps. Secondly, in the early stage of smart waste bins entering the community, there are waste classification volunteers in front of each smart garbage bin to guide residents to use.

Acknowledgement

This research was supported by the Academic Research Projects of Beijing Union University (No. SK30202105)

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