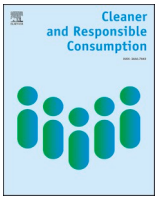
Cleaner and Responsible Consumption 7 (2022) 100087

Contents lists available at ScienceDirect

Cleaner and Responsible Consumption

journal homepage: www.journals.elsevier.com/cleaner-and-responsible-consumption



An empirical study on the types of consumers and their preferences for E-waste recycling with a points system

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ARTICLE INFO

Keywords:
E-waste recycling
Consumer type
Points system
Theory of planned behavior

ABSTRACT

Improper disposal of electronical waste (e-waste) causes harm to both public health and the environment, and how to effectively recycle and reduce electronical waste has become a common concern around the world. This study focuses on the design of the points system to encourage consumer participation in e-waste recycling programs. Based on the Theory of Planned Behavior (TPB) model, a semi-experimental design method was applied to influence consumer cognition and behavioral intention through information provision in survey design. Two surveys were conducted in two years apart to understand the temporal trend of consumer types and their preferences for the design of e-waste recycling points program. By comparing consumer types before and after the introduction of the points system, the research concludes that the points system has a positive impact on consumers' environmental consciousness and recycling intention. The results show that consumers generally have a strong sense of environmental protection after the introduction of the recycling points system, and that different consumer types differ significantly on subjective norm, perceived behavioral control, recycling motivation, points incentives, points redemption and recycling behavioral intentions. This suggests that the design of the points system can not only promote consumers' environmental awareness but also stimulate consumers to actively participate in e-waste recycling. Finally, several policy recommendations are discussed to help apply the points system to the empirical design of e-waste recycling programs.

1. Introduction

Economic development promotes the use and upgrades of electronic devices and equipment, which results in an increasing amount of waste electrical and electronic equipment (WEEE). Electronic waste or e-waste refers to electronic products that are no longer useable and are therefore dumped or recycled. In 2019, 53.6 million metric tons (Mt) of e-waste was generated worldwide, up by 21 percent in just five years, while only 17.4 percent of the e-waste was collected and recycled (Forti et al., 2020). Asian countries were the largest contributor to the global e-waste problem, with the Asian continent generating 18.2 Mt of e-waste (about one third of global total) in 2019 (Gollakota, 2020).

E-waste often has a larger environmental impact than municipal waste. On the one hand, e-waste contains a range of toxic chemicals such as lead, chromium and other heavy metals and chemical additives. Improper disposal of e-waste such as random burial and incineration can cause considerable damage to the environment. On the other hand, electrical equipment is responsible for 10–20% of anthropological contributions to environmental damages (i.e., depletion of non-renewable sources, greenhouse effect, air acidification, and dust emissions) (Labouze and Monier, 2003). In particular, the production and usage of washing machines, refrigerators and freezers, telecommunications devices, and audio and video equipment are responsible for approximately 8% of the overall global warming potential generated by a household (Tukker et al., 2005).

China is the world's largest importer and producer of e-waste (Neha and Emma, 2020), with over 70% of all global e-waste ending up in the world's largest dumpsites in China (Tyrone, 2015). In 2020, China processed about 2.306 Mt of WEEE, with a formal recycling rate of less than 32% (CHEARI, 2021). Such a grim recycling situation in China calls for empirical research that investigates recycling incentives and policies and explores motivations for consumer participation in e-waste

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https://doi.org/10.1016/j.clrc.2022.100087
Received 14 March 2022; Received in revised form 8 September 2022; Accepted 29 October 2022
Available online 7 November 2022

recycling programs.

The Chinese government has adopted a series of policies to manage e-waste (see a comprehensive review by Yu et al. (2010)). A few studies have examined the effectiveness of the command-and-control regulations. For instance, Shinkuma and Managi (2010) study the license scheme for e-waste recycling in China, in which only licensed recyclers are allowed to carry out e-waste recycling activities. They find that a license scheme is only effective if disposers of e-waste are obliged and have a high responsibility to sell e-waste to license holders.

Given the limitations of the command-and-control regulations, many have proposed the use of market-based approach to promote e-waste recycling behaviors and incentivize consumer participation in e-waste recycling programs (Arain et al., 2020). Yu et al. (2010) propose a deposit system to incentivize consumer participation in China. Shevchenko et al. (2019) find that in Asian countries, financial factors largely determine consumers' recycling behaviors, hence an economic incentive in the form of an electronic bonus card system can help improve e-waste collection rates.

As a tool to improve customer loyalty in marketing, the points reward system can provide incentives and motivations to consumers, and has been widely used in aviation, commerce, service and other industries (Dick and Basu, 1994). Although few studies argue that introducing the points system to e-waste recycling may effectively improve the recycling rate, enhance the environmental awareness of consumers, cultivate their environmental habits as well as achieve the win-win effect of ecological and economic benefits (Zhong and Huang, 2016; Wang et al., 2016), empirical research on the points system in e-waste recycling is still lacking, with even rare emphasis on its application in China. Some empirical evidence has demonstrated that redeemable point collection systems can encourage the public to return and recycle their household e-waste in Malaysia (Yong et al., 2019). Previous study has shown that consumers attitude and their context have a significant impact on their willingness to participate in e-waste recycling (Zhong and Huang, 2016). However, how the points system works in China, and how it influences consumer attitudes towards and preferences for e-waste recycling has not been thoroughly studied in the literature. To fill this research gap, this paper examines the impact of an e-waste recycling program points system on consumer attitude and preferences for recycling using data collected from two national surveys conducted in China in 2016 and 2018. Specifically, this research focuses on consumers' recycling behavior changes under the influence of the points system, and the relationship between consumer types and the influencing factors of recycling behaviors.

The content of this paper is organized as follows. A literature review on factors influencing consumer recycling behaviors, empirical application of points system, consumer types and the Theory of Planned Behavior is presented in Section 2. Research methodology is discussed in Section 3. Section 4 presents the questionnaire survey and the corresponding data analysis results. Section 5 discusses the analysis of the second questionnaire survey and compares the results with the first one. Finally, suggestions are provided in Section 6 and conclusions and prospects of future research in Section 7.

2. Literature review

This section presents a literature review on factors influencing consumer recycling behaviors, empirical application of points system, consumer types and the Theory of Planned Behavior.

2.1. Factor influencing consumer recycling behaviors

External factors such as government policies and incentives are often used to influence consumers' e-waste recycling behaviors. Catherine et al. (2002) study the introduction of a disposal fee system in Japan, which resulted in a 25% increase in illegal recycling. Shao (2008) proposes a deposit system that was initially effective but introduced extra burden of deposit fee to consumers. Ping (2009) analyzes the stimulating effect of the eco-friendly home appliances points reward system on consumers' environmental protection consumption. Among the policy instruments, charges are punitive, while the deposit system and the points reward system are economic measures. Compared with the deposit system, the points reward system is more consumer-friendly and rewarding.

In addition to external factors, consumers' internal motivation is another important factor influencing consumer e-waste recycling behaviors (De Young, 1993; Lan and Zhu, 2009). Perceived behavior control has become the primary influencing factor of recycling behaviors, and consumers' evolving psychology can play an important role in long-term recycling behavior changes. Therefore, it is necessary to explore a long-term mechanism to cultivate consumer environmental awareness and influence consumer behaviors. The non-price mechanism of the points reward system offers an alternative policy choice, however, its impact on consumer e-waste recycling behaviors has not been thoroughly studied.

2.2. Empirical application of the points system

The points system has been adopted and implemented in many regions. For instance, Japan launched the environmental protection points system in 2009. In 2011, the Ministry of Environment in Japan expanded the environmental protection points system and deeply integrated it with other environmental protection activities, such as consumption stimulation and energy conservation, which made the individual low-carbon consumption lifestyle consistent with the national environment protection goal and promoted the development of environmental protection industry. These measures are in line with the principle of "incentive compatibility" (Li, 2014; Yin, 2011). In Shanghai, China, the points reward system was launched by Alah Environmental Protection & Renewable Resources Public Service Platform which greatly reduces illegal recycling and recruits even informal recyclers. At the same time, accumulating points also increase customer engagement and fun, and fun is one of the elements of gamification design (Liu et al., 2017).

2.3. Consumer types based on environmental awareness

In terms of consumer types, Roger Organization, a private research organization in the United States, has conducted a close research on the consumer groups in the United States since 1990 (Jovanovic, 1999). They divided consumers into five groups based on their commitment to the environment, and the most environment-friendly consumers are called green consumers. Peattie and Crane (2005) define green consumers as those who are eco-conscious and able to proactively purchase green products. In a broad sense, green consumers are anyone who has green consumption awareness and actively implements green consumption. One of the reports from AliResearch indicates environment-friendly consumers have become one of the five emerging new consumer groups in China. It finds that 16.2% of the consumers on Alibaba's China retail marketplaces bought five or more green products in 2015, 12.8% up from 3.4% in 2011. Equally important, these customers are willing to pay higher prices—33% more, on average—for sustainable products (Boston Consulting Group and AliResearch Institute, 2017). Jun (2003) defines green consumer as consumers who care about the ecological environment and have realistic and potential purchase intention, and purchase ability for green products and services. They would purposefully avoid products with excessive resource depletion and negative environmental and health impact, excessive packaging products, and products that involve the use of endangered species or other animals in experiment phases.

2.4. Theory of Planned Behavior

The Theory of Planned Behavior (TPB) was developed by social psychologists and has been widely employed as a tool to aid our understanding and prediction of an individual's intention to engage in a behavior at a specific time and place. It posits that individual behavior is driven by behavior intentions, which are a function of three determinants: an individual's attitude toward the behavior, subjective norms, and perceived behavioral control (Ajzen, 1991). The TPB details how the influences upon an individual influence their decision to follow a particular behavior. Given a stable behavioral context, when all three variables have positive effects, the influence of habit on consumer behaviors can be ignored (Ajzen, 2002; Bamberg et al., 2003).

Because of its explanatory power of the relationship between people's intention and behaviors, TPB has been widely applied to explain consumer e-waste recycling behaviors (Aboelmaged, 2021). Ylä-Mella et al. (2015) apply TPB to examine consumers' awareness and perceptions towards mobile phone recycling and reuse in Finland. They find that consumers' awareness of the importance and existence of waste recovery system does not necessarily translate to recycling behavior. In the Chinese context, the TPB has been used to understand determinants of residents' e-waste recycling behaviors and behavior intentions (Wang et al., 2016; Zhang et al., 2016). Wang et al. (2016) find that public perceptions of informal recycling affect their behavior intentions. Zhang et al. (2016) confirm the gap between e-waste recycling behavioral intention and behavior, and they find that enhanced accessibility to recycling facilities would encourage the recycling behavior.

Based on the above literature review, it can be seen that empirical application of the points-system in e-waste recycling is still limited. There is also a lack of understanding about how consumers perceive and respond to e-waste recycling with a points system. Therefore, in this study, empirical survey data are collected and analyzed to test if the TPB can be applied to better understand the context of e-waste recycling under a points reward system in China. The research questions of this paper are: 1) What are the different customer types engaged in e-waste recycling in China? 2) How do factors that influence e-waste recycling behaviors differ across different consumer types? 3) How does the exposure to new information about points reward system influence consumer types and their perceptions and preferences on e-waste recycling? To answer these questions, this research uses TPB as the theoretical framework to understand consumer type classifications and the mechanisms that the points system influences consumers' recycling behaviors. Specifically, survey question design is guided by the theoretical model presented in Fig. 1. Based on the TPB, it is expected that individual recycling behavior is driven by recycling behavior intentions (Z), which is determined by an individual's attitude toward the recycling behavior (X1), subjective norms (X2), and perceived behavioral control (X3). Besides psychological factors, several other factors are introduced to the model: the points system incentives (X6), the points system design features (X5, X7, X8), and recycling motivation (X4). Their impacts on consumer recycling behavioral intention are tested.

The hypothesis of this paper is that if the three variables (individual's attitude toward behavior, subjective norms, and perceived behavioral control) all have a positive impact on consumer e-waste recycling behaviors under a points reward system, the influence of consumer habits can be neglected, thus collectively the points system will have a positive impact on consumers' e-waste recycling behaviors to certain extent.

3. Data and methodology

3.1. Survey design and data collection

The survey method is used in this research to collect data on consumer environmental awareness and recycling behaviors. Two surveys were conducted in 2016 and 2018, respectively through an online crowdsourcing platform in mainland China (Wenjuanxing), which provides similar service to Amazon Mechanical Turk and has been widely used by scholars in China as a reliable survey tool (see for instance Wu et al., 2018). Wenjuanxing distributes survey questionnaires among a pool of potential respondents they maintain, which totals around 6.2 million people and serves as a representative sample of the general population in China. Before the formal survey, a pilot survey with quality-control questions was distributed to potential respondents in this pool. The formal survey was only revealed to respondents who passed the quality-control questions, and those who agreed to spend time on the formal survey. Therefore, the willingness to participate in the surveys were controlled to be unrelated to participants' interests in the actual topic of e-waste recycling. In addition, lottery-based incentives were provided to increase response rates and reduce selection basis.

In the two surveys, a semi-experimental design method was applied to understand how consumers' responses change when provided with information about the points reward system. Each survey consisted two sections. The first section asked questions about consumer environmental awareness, recycling habits and consumer types. Then, a brief introduction of the points reward system for e-waste recycling was provided. The second section collected data on consumers' preferences for the points reward system and consumer types. By analyzing responses before and after the provision of information about the points system, it allows us to investigate whether the points system has an impact on consumer types and their preferences for e-waste recycling.

Survey questions were designed based on the theoretical model presented in Fig. 1. For instance, Questions 1–4 were used to collect information on consumer attitude on recycling and environmental protection, while Question 5–7 collected information on subjective

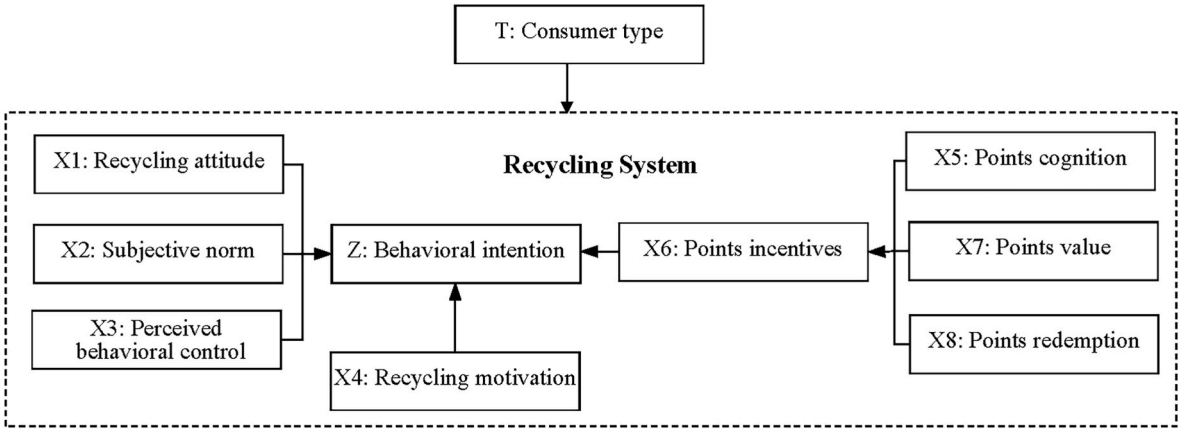


Fig. 1. Theoretical model of consumer participation in e-waste recycling.

norm's impact on consumers' willingness to participate in recycling. Details about the measurement variables and questions for the two surveys are presented in Supplementary Information 1 & 2 (SI-1 & SI-2).

3.2. Quantitative data analysis

Clustering analysis is used to classify consumer types, and the variance analysis method is used to evaluate how different consumer types differ in factors that influence behaviors. Hierarchical clustering method can adapt to different requirements due to the flexible calculation method of distance between the classes. The basic idea is to treat samples as a class and specify the distance between samples and the distance between classes. Compared with the K-means clustering algorithm, the hierarchical clustering method automatically lists the categories according to the distance between the data. It is not necessary to formulate the number of classifications according to the sample spatial distribution. Instead, a dendrogram can be obtained through the hierarchical clustering method and determine the types of consumers in the questionnaire (Hu, 2007). However, the initial points selection of the K-means clustering algorithm is unstable and random, which may cause the instability of clustering results (Feng and Zhang, 2010). Therefore, this paper uses the hierarchical clustering method to analyze consumer types in relation to e-waste recycling in the context with or without the knowledge of the points system. All data were processed and analyzed using SPSS.

4. Results: the first survey in 2016

4.1. Reliability and validity

In the first survey, a total of 600 questionnaires were distributed through online platform and on-site surveys in 29 out of 34 administrative regions including centrally-administered municipalities in China (details shown in SI-1), and 510 valid questionnaires were returned with an effective response rate of 85%. The reliability test of questionnaire was performed. The Cronbach's alpha was 0.877, the Kaiser-Meyer-Olkin (KMO) was 0.886 and the value of Bartlett's sphericity test was 0.000. Therefore, this questionnaire has good reliability and validity.

Table 1 shows the descriptive statics of respondents in the two surveys. For the first survey, the ratio between male and female was 239:271, around 1:1.13. 86.5% of survey respondents were aged 20–40.69% had bachelor's degree, 12.4% had associate degree and 11.2% had master's degree or above. In terms of occupation, 45.5% were employees of sole proprietorship, joint venture or private enterprise and 25.1% came from government, state-owned enterprises, public institutions. 70% of the respondents fell within the income range of 3000 to 10000 RMB. The survey participants were from different provinces of China, with the most participants coming from Guangdong, Shandong, Beijing and Shanghai. Detailed sample information is listed in SI-1.

Table 1
Summary statistics of the demographic information of respondents participated in the two surveys.

		First survey		Second survey	
Variable	Category	Frequency	Percent	Frequency	Percent
Gender	Male	239	46.9	256	41.0
	Female	271	53.1	369	59.0
Age	Below 20	15	2.9	43	6.9
	21–30	263	51.6	330	52.8
	31–40	178	34.9	198	31.7
	41–50	38	7.5	43	6.9
	Over 50	16	3.1	11	1.8
Education	Senior high school or below	38	7.5	23	3.7
	Associate degree	63	12.4	80	12.8
	Bachelor degree	352	69.0	443	70.9
	Master and above	57	11.2	79	12.6
Personal Income	Below 3000RMB	80	15.7	123	19.7
	3000-10000 RMB	358	70.2	427	68.3
	Over 10000RMB	72	14.1	75	12.0
Total		510	100	625	100.0

4.2. Consumer environmental consciousness

The survey results show that the mean value of Question 1[1] is 4.60 (1- "strongly disagree", 5- "strongly agree", and the same scale applies to other survey questions if there is no special explanation). The mean value of Question 2[2] is 4.29, and the mode is 5 respectively, indicating that consumers generally have a favorable attitude towards recycling and view e-waste recycling as environmentally beneficial.

4.3. Consumer types under the No points system scenario

In this paper, the economic and environment-friendly questions in the surveys are used as the index to perform clustering analysis on consumer types before and after the provision of information on the points system in the survey respectively. When respondents are unaware of the points system of e-waste recycling, Question 14 and 15[3] in the survey are designed to learn about consumers' attitude towards the cost and environmental benefits of e-waste recycling. Question 14 and Question 15 are also used to measure consumers' concern over recycling cost and environmental benefits, respectively. The cluster analysis result shows that consumers can be divided into three categories: economical (ECO), environment friendly (ENV) and general or indifferent (GEN).

Consumer preferences range from completely disagree to fully agree, corresponding to 1–5 points respectively. The consumer types, numbers, mean scores of Question 14 and 15 and key characteristics of respondents in this scenario are shown in Table 2 - "No points system scenario" row. The accuracy of classification definition can be ensured from both the global mean value and the characteristics of each sample.

4.4. Consumer types under the points system scenario

In the "points system scenario", a brief introduction of the points system was provided to the respondents before the survey, so that the consumers have the knowledge of points recycling for environmental protection. This paper analyzes whether points system will have an impact on the original consumer type classifications, that is, whether introducing the points system in the survey changes consumers' preferences to some extent. Under the points system scenario, Question 27 and Question 28[4] are used to measure consumers' economic preference and environmental preference respectively. The result shows that consumers can be divided into three categories: economical (ECO), both economic and environment friendly (EEF), and environment friendly

[1] Question 1(I think e-waste recycling is good for the environment) (1- "strongly disagree", 5- "strongly agree", and the same scale applies to other survey questions if there is no special explanation).

[2] Question 2 (I think participating in e-waste recycling can contribute to environmental protection and bring me pleasure and a sense of achievement).

[3] Question 14 (I am more concerned about the recycling price of e-waste) and Question 15 (I care about whether participating in recycling can improve my environmental protection image).

[4] Question 27 (I am more concerned about whether the recovered points have economic value, such as whether they can be directly redeemed) and Question 28 (I am more concerned about whether recycling points can improve my environmental image).

Table 2
Descriptive statistical analysis of consumer types without and under points system.

	Consumer type	Number of people	Mean score of economic preference		Mean score of environmental preference	Feature
No points system scenario	ECO	119	4.32	>	2.70	The mean value of economic preference is higher than that of environmental preference. **More focus on economic benefit**
	ENV	142	3.76	<	4.27	The mean value of economic preference is smaller than that of environmental preference **More attention to environmental image**
	GEN	249	2.58	≈	2.70	The mean value of economic preference and environmental preference is below 3 **Not sensitive to economic benefits or environmental image**
Points system scenario	ECO	277	4.44	>	3.06	The mean value of economic preference is higher than that of environmental preference **More focus on economic benefits**
	EEF	174	4.05	≈	4.05	The mean value of economic and environmental preference is around 4 **Consider economic benefits as important as environmental image or irrelevant**
	ENV	59	3.25	<	4.34	The mean value of economic preference is smaller than that of environmental preference **Pay more attention to environmental image**

Note: higher score indicates higher preference for this item. Therefore, when economic preference score is higher than environmental preference score, economic preference will be more preferred, and so on.

(ENV). The consumer types, numbers, mean values of Question 27 and 28, and key characteristics of respondents are shown in Table 2 above.

4.5. The impact of points system on consumer types

After introducing the points system, the comparative analysis of various consumers' recycling indicators shows that the cognitive differences of consumers are very significant and paired sample *t*-test result reached the level of 0.00. Q14 and Q27's paired difference mean value is −0.857, and Q15 and Q28's paired difference mean value is −0.41, which mean both environmental and economic preference values increased after the introduction of new information about the points system.

Fig. 2 shows the proportion of consumer types before and after exposure to the idea of the points system in this survey. In absence of the points system, consumers can be categorized into three types: ECO, ENV and GEN. After the introduction of the points system, consumer types become ECO, EEF and ENV. We can intuitively conclude from the classification that the implementation of the points system changes the GEN (indifferent) consumers into consumers with clear preference types.

Based on the results shown in Fig. 2a, in absence of the points system, the proportion of GEN consumers, who are indifferent between economic benefits and environmental protection, is 48.82% and far exceeds the proportion of ECO and ENV consumers. However, as shown in Fig. 2b, the proportion of ECO consumers has increased significantly from 23.33% to 54.31% after the introduction of the points system. This may be caused by the economic incentive provided by the points incentive system. In addition, there is a "distance" between ENV consumers and EEF consumers based on the clustering analysis results, so they have become two separate categories respectively. The GEN consumers are largely replaced by EEF consumers who care about both economic benefits and environmental protection.

As shown as Fig. 3a below, for the original ECO consumer groups, introduction of the points system can not only convert a part of consumers into EEF, but also turn a small part to ENV consumers. For the group of ENV consumers, although providing the information about the points system has turned some of them into ECO type, the number of consumers who remain environmentally friendly and gain economic attributes based on environmental type still account for a large proportion within ENV consumers (25/59). For the GEN consumer groups, the impact of the points system plays an important role and most of them have shown obvious preference. Therefore, the points system promotes the environmental consciousness of consumers to a certain extent.

Results also show that introducing the points system makes the consumer preference more obvious and expands the proportion of ECO and EEF consumers to a certain degree. This means that in absence of a points system, consumers' awareness of environmental protection is latent. Under the promotion of the points system, environmental awareness can become more visible.

4.5.1. Different types of consumers' preferences to participate in the points system

This section focuses on the preferences of the three types of consumers on the points system. The following conclusions are drawn:

(1) All three types of consumers believe that they should obtain certain economic benefits and a sense of achievement in environmental protection from recycling.

According to Question 27 and Question 28, the mean values of the three types of consumers are around 3 or 4, meaning all believe they should obtain certain economic benefits and a sense of achievement of environmental protection from recycling.

(2) ECO consumers tend to show a strong sense of recycling.

The mean values of responses to Question 25and Question 26[5] are calculated and compared across different consumer types. Compared with ENV consumers, ECO consumers are more likely to be motivated by the points system and are more enthusiastic for recycling under the points system.

(3) ECO consumers and ENV consumers have significantly different preferences on the design of points redemption.

Based on Fig. 4a, a large proportion of consumers across the three

[5] Question 25 (I think the appropriate rules for the use of points can motivate me to participate in recycling) and Question 26 (I will take the initiative to participate in e-waste recycling if the points system was implemented).

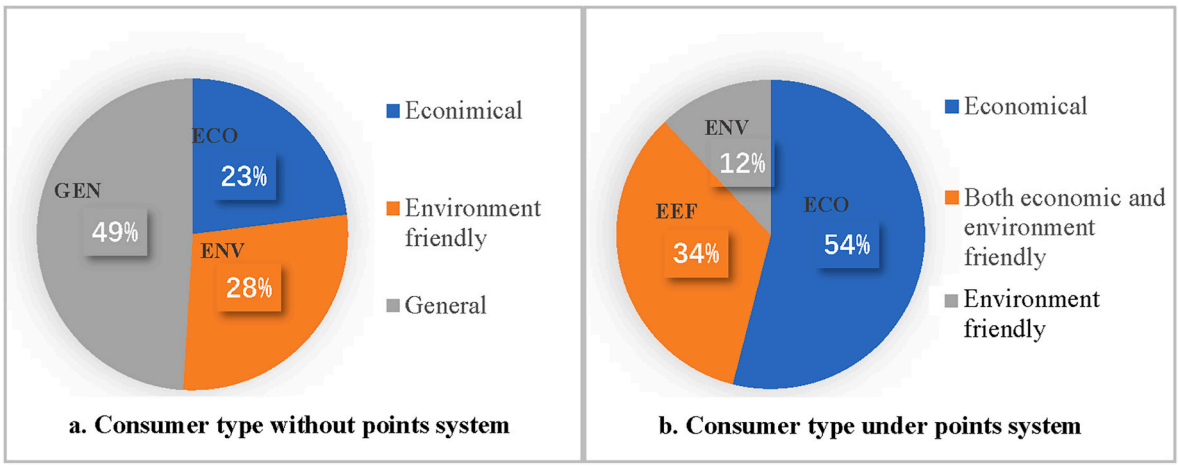


Fig. 2. Consumer type scale pie chart.

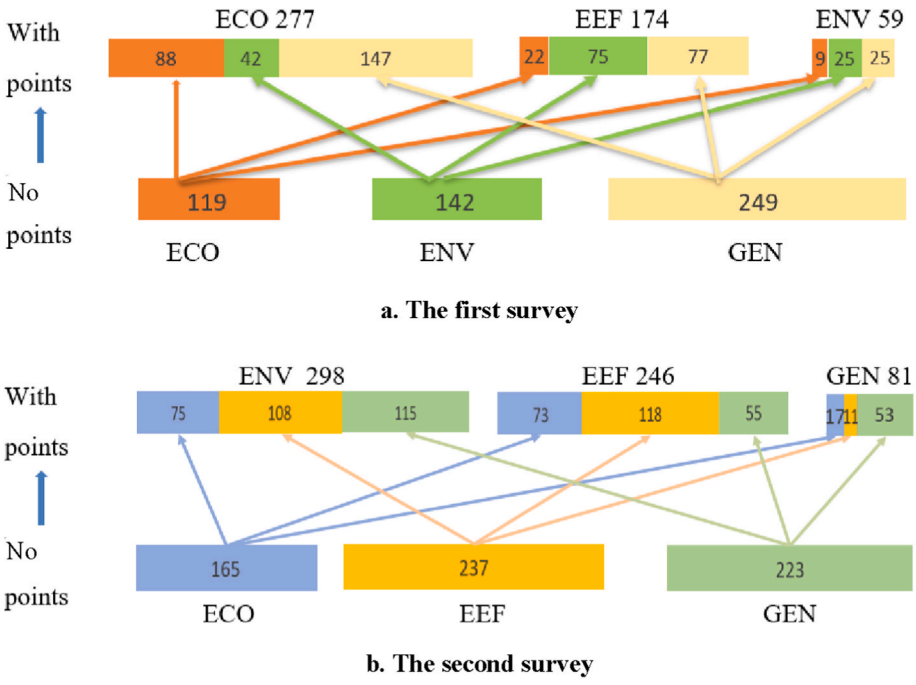


Fig. 3. Consumer type transition.

types prefer points redemption that can bring economic benefits, such as returning cash and exchanging goods. In particular, a higher percentage of ECO consumers prefer cash return and good exchange, compared to those of the other two consumer types. A higher percentage of ENV consumers prefer exchange points for services and discounts on environmental goods than those of the ECO and EEF consumer types.

4.5.2. The influence of the points system on consumer willingness to recycle

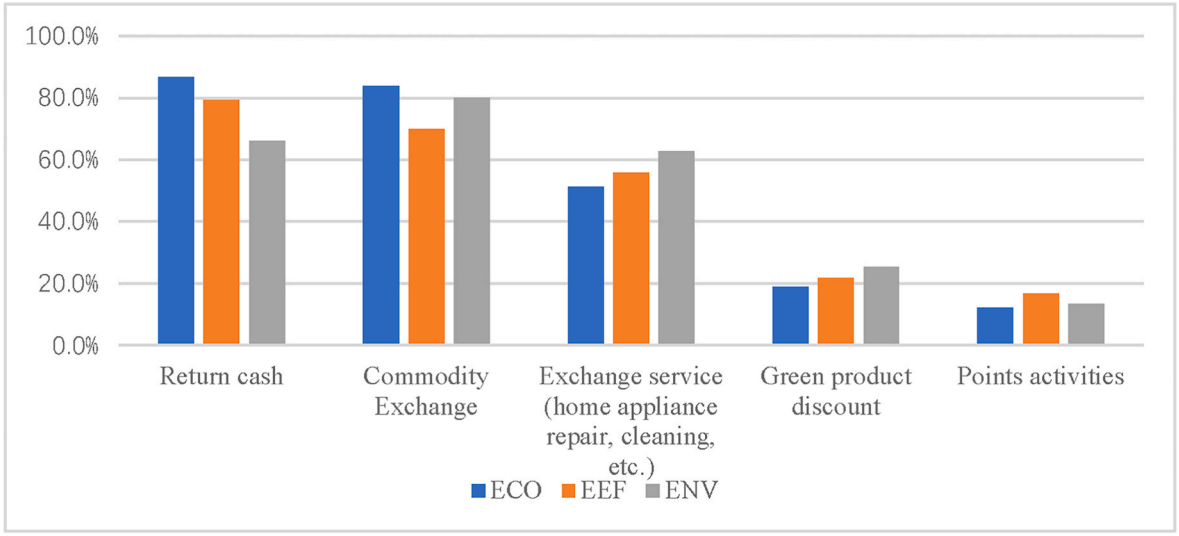
In this questionnaire, each consumer was asked to rate their willingness to participate in recycling on a scale of 0 to 10 with or without a points system respectively. A score of 0 is defined as "very unwilling" and a score of 10 is defined as "very willing". Paired sample t-tests were conducted for two variables constructed based on Q21 and Q41[6] respectively. The result indicates consumers' willingness to participate in recycling differs significantly under the two scenarios. Without the points system, the mean value and standard deviation were 8.21 and 1.713, while under the points system, the mean value and standard deviation were 8.42 and 1.559. According to the analysis, the mean value increased by 2.5%, and under the points system, no consumers were "very reluctant" to participate in the recycling of e-waste. In conclusion, the points system can play a positive role in promoting consumers' willingness to recycle e-waste.

4.5.3. Influencing factors of e-waste recycling behaviors for different consumer types

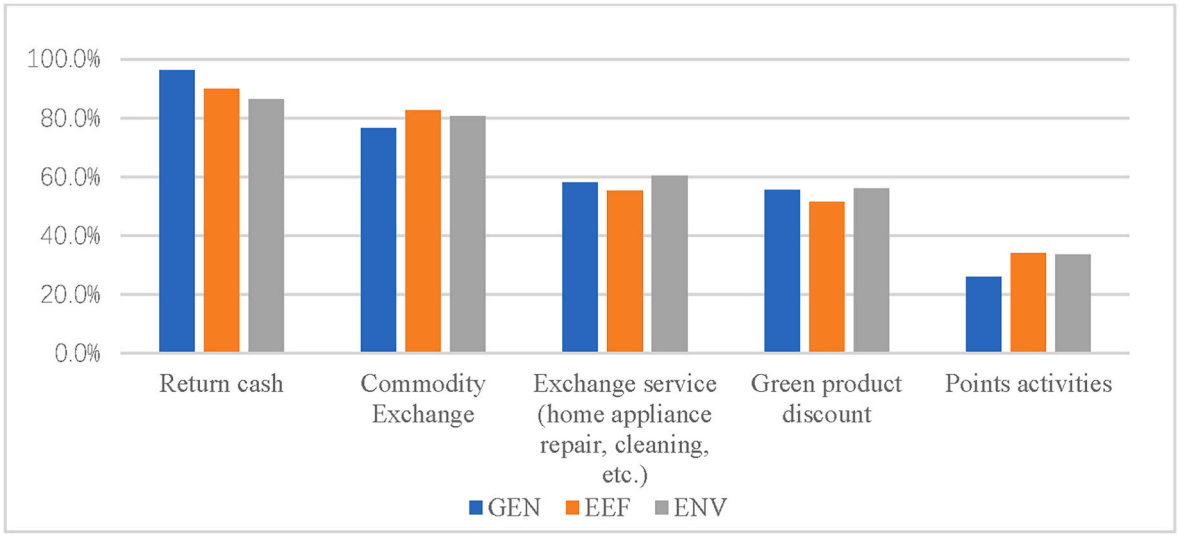
This section examines how respondents score on a range of factors that influence e-waste recycling behaviors. Eight factors including recycling attitude, subjective norms, perceived behavior control, recycling motivation, points incentive, points cognition, points value, and points redemption are analyzed for different consumer types.

Fig. 5a presents mean values of these factors. It is concluded that ENV consumers tend to score the highest in all factors except for

[6] Q21 (Are you willing to take the initiative to participate in e-waste recycling in the future?) and Q41(Are you willing to take the initiative to participate in e-waste recycling with the implementation of points system in the future?).



a. First survey



b-Second survey

Fig. 4. Points redemption preferences of different types of consumers.

recycling motivation and point cognition. This indicates that ENV consumers show a positive attitude towards recycling and the points system in all aspects under the promotion of the points system.

Variance analysis was carried out on the eight factors with consumer types being the dependent variable. The result shows that different consumer types differ significantly in six factors, including subjective norms, perceived behavior control, recycling motivation, points incentive, points redemption, and behavioral intention.

5. Results: the second survey in 2018

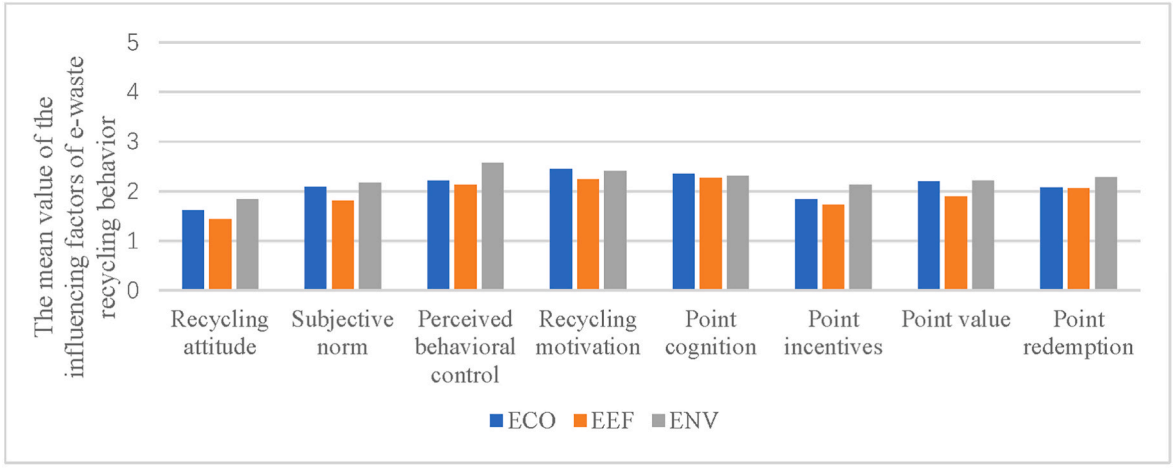
In order to investigate the temporal changes in consumer types and preferences on e-waste recycling and the points system, the second survey was carried out in 2018, two years after the first survey. The second survey includes the same questions from the first survey, as well as 13 new questions, which are not used or analyzed in this paper. A table comparing the question numbers in the two surveys is now presented in Appendix I.

In the second survey, a total of 700 questionnaires were distributed through online and on-site surveys in 29 out of 34 administrative regions including centrally-administered municipalities in China, and 625 valid questionnaires were recovered with an effective response rate of 89.29%. Specific items of measurement variables and all detail survey are shown in Supplementary Information 2 (SI-2).

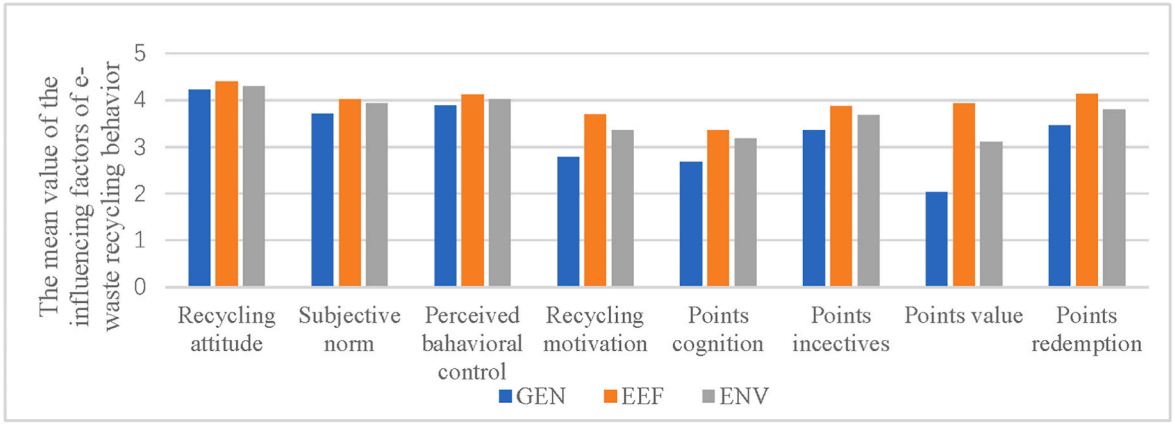
In the sample (shown in Table 1), the ratio between male and female is 256:369, around 1:1.4. 84.5% of survey respondents were between 20 and 40 years old. 70.9% had bachelor's degree, 12.8% had associate degree and 12.6% had master's degree or above. In terms of occupation, 60.2% of respondents were enterprise staff and 20.0% were students. Income is in the range of 3000 to 10000 RMB. The survey participants were from different provinces of China, with Guangdong, Shandong, Beijing and Shanghai had the most respondents. All the detailed information is listed in SI-2.

The analysis of consumers' environmental awareness according to Q31and Q32[7] in the second survey shows that the public generally

[7] Q31 (I think e-waste recycling is good for the environment.) and Q32 (I think participating in recycling can contribute to environmental protection and bring me pleasure and a sense of achievement.).



a-First survey



b-Second survey

Fig. 5. The mean value of the influencing factors of e-waste recycling behavior.

believe that participating in e-waste recycling is conducive to environmental protection and can make them feel happy and fulfilled. The mean values of responses to Q31 and Q32 are 4.43 and 4.21 respectively, which are similar to the mean values of responses in the first survey (4.6 and 4.29 respectively).

5.1. Determination of consumer type and the impact of points system

Four questions[8] in the second survey are selected to analyze the consumer types before and after the introduction of the points system. The system clustering method was used for analysis and the results are shown in Table 3.

As shown in Table 3, in the context of no points system, consumers are divided into three types: ECO, EEF and GEN (namely indifferent). After introducing the points system in the survey, consumer types become ENV, EEF and GEN. Fig. 3 shows how the consumer types in the two questionnaires were converted under the influence of the points system. It shows that ECO consumers are transformed into other types and the number of GEN consumers is significantly reduced after the points system is introduced.

Furthermore, we assigned rough weights to the four consumer types based on their environmental friendliness or contribution for environment protection. Let $W_{\mathrm{GEN}} = a$, $W_{\mathrm{ECO}} = b$, $W_{\mathrm{EEF}} = c$, $W_{\mathrm{ENV}} = d$ $(0<a<b<c<d)$. It is supposed that $b = a+\theta, c = b+\sigma, d = c+\mu$, the values of θ, σ, μ are positive and approximately the same. The total score of respondents' environmental friendliness can be calculated using the formula below:

$$Score = \sum_i N_i * W_i \Big/ \sum_i N_i$$

N_i is the number of consumers of each type, W_i is the weight assigned to each consumer type, and i is the consumer type (i.e., GEN, ECO, EEF, ENV). It can calculate the changes in consumer environmental friendliness scores before and after the introduction of the points system for both surveys. For the second survey,

$$\Delta Score_2 = Score_{with2} - Score_{without2} = 142\theta + 307\sigma + 298\mu > 0$$

it shows that consumers' environmental friendliness scores are larger after the points system is introduced. For the first survey,

$$\Delta Score_1 = Score_{with1} - Score_{without1} = 249\theta + 91\sigma - 83\mu,$$

it means under the condition of $\mu < 3\theta + \frac{91}{83}\sigma$, $Score_1$ must be positive. Because the values of θ, σ, μ are not significantly different, the condition above is easy to satisfy. Therefore, in general, the points system can greatly improve consumers' environmental friendliness scores.

[8] Q33 (Q14 in 1st survey: I am more concerned about the recycling price of e-waste), Q34 (Q15 in 1st survey: I care about whether participating in recycling can improve my environmental protection image), Q44 (Q27 in 1st survey: I am more concerned about whether the collected points have economic value such as whether they can be directly redeemed) and Q45 (Q28 in 1st survey: I am more concerned about whether recycling points can improve my environmental image).

Table 3
Descriptive statistical analysis of consumer types without and under points system (the second survey).

	Consumer type	Number of people	Mean score of economic preference		Mean score of environmental preference	feature
No points system scenario	ECO	165	4.29	>	2.90	The mean value of economic preference is higher than that of environmental preference. **More focus on economic benefit**
	EEF	237	3.92	<	4.33	The mean value of economic preference and environmental preference is above 3 **Consider economic benefits as important as environmental image**
	GEN	223	2.43	≈	2.60	The mean value of economic preference and environmental preference is below 3 **Not sensitive to economic benefits or environmental image**
Points system scenario	ENV	298	2.85	<	3.35	The mean value of economic preference is lower than that of environmental preference. **Pay more attention to environmental image**
	EEF	246	4.24	>	3.61	The mean value of economic preference and environmental preference is above 3 **Consider economic benefits as important as environmental image**
	GEN	81	2.26	≈	1.80	The mean value of economic preference and environmental preference is below 3 **Not sensitive to economic benefits or environmental image**

Note: higher score indicates more preference for this item

To simulate the results, assume that a=1, b=2, c=3, and d=4. Respondents' environmental friendliness scores for the two surveys are presented in Table 4. It can be seen that the total environmental protection score of consumers has increased significantly after the introduction of the points system, which shows that consumers' environmental awareness has been improved under the influence of the points system, and the types of consumers have changed to a more positive direction of environmental protection.

5.2. Different types of consumers' preference to participate in the points system

The analysis of points redemption mechanisms (as shown in the Fig. 4-b) shows the three types of consumers prefer to use points to exchange economic services, namely, return of cash and exchange of small commodities. Also, there is a significant increase in the mean of consumers' recycling influencing factors for e-waste recycling behavior in the second survey. Compared with GEN and EEF consumers, a higher proportion of ENV consumers incline to use points to exchange for environment-related services, such as home appliance maintenance and discounts of environment-friendly products. EEF consumers are the most inclined to participate in exchange of small commodities and points activities among the three types of consumers.

Table 4
Consumer type conversion trend analysis.

		GEN	ECO	EEF	ENV	$Score = \sum_i N_i * W_i \Big/ \sum_i N_i$
The first survey	No points	249	119	0	142	2.07
	With points	0	277	174	59	2.57
The second survey	No points	223	165	237	0	2.02
	With points	81	0	246	298	3.21

5.3. The influence of the points system on consumer willingness to recycle

The paired samples T-test was carried for Q41 and Q54[9] and the result shows that consumers' willingness to participate in the recycling changes significantly before and after introducing the points system (the t-test statistic is equal to 0.00). The conclusion is consistent with the first questionnaire: the practice of points system significantly enhances the consumer awareness of recycling and positively promotes the e-waste recycling business.

5.4. Influencing factors of e-waste recycling behaviors for different consumer types

As shown in Fig. 5b, EEF consumers on average score the highest among all the influencing factors, indicating that under the influence of the points system, EEF consumers are more willing to participate in recycle and the points system compared with the other two types of consumers.

Variance analysis was carried out on the eight factors with the consumer types being the dependent variables. The results show that consumer types differ significantly on five factors that can influence recycling behaviors, which are recycling motivation, perceived behavior control, points cognition, points incentive and perceived behavior control under points context.

6. Discussion

Based on the results of the two surveys, it indicates that Chinese consumers generally have a strong awareness of environment protection and the points system can promote the transformation of GEN consumers with no obvious preference for economy or environment to consumers with clear preferences, and visualized awareness. Based on our results, we discuss relevant policy implications.

[9] Q41(Are you willing to take the initiative to participate in e-waste recycling with the implementation of points system in the future? 0-"very unwilling", 10-"very willing") and Q54 (Are you willing to take the initiative to participate in e-waste recycling with the implementation of points system in the future? 0-"very unwilling", 10- "very willing").

6.1. Enhance publicity and education for recycling

Introducing the points system plays an important role in promoting consumers' environmental awareness and behaviors. It is helpful for the government and media to provide relevant information about e-waste and e-waste recycling to the general public. For instance, government can use information and education policies (i.e., workshops, public campaigns) to educate the public about the harm of e-waste, the importance of e-waste recycling and various types of recycling programs. Government subsidies can also be provided to private companies and non-profit organizations who engage in the design and implementation of e-waste recycling programs. Meanwhile, retailers or organizations implementing points system should actively promote the recycling points system to enhance consumer awareness of e-waste recycling and cultivate green consumers.

6.2. Customize points redemption mechanisms by consumer type

When implementing the points system, it may be helpful to emphasize the dual economic and environmental benefits of the points system for retailers or organizations participating in e-waste recycling. It will also be useful to recommend appropriate points redemption items and conditions for different types of consumers. For example, consider cash or items return for economic consumers who prefer services related to economic benefit. Recommend discount on maintenance services and green products to consumers who wish for exchange of life services. Considering that more diverse redemptions will increase costs to some extent, the points system can be implemented in cooperation with other environmental protection product providers or life service merchants to enhance the enthusiasm of consumers to participate in recycling.

6.3. Increase the convenience of recycling

The current recycling facilities can be improved to enhance the convenience of recycling, improve public understanding of recycling channels, and protect public privacy of recycled items, etc. Meanwhile, the last section of this paper also proves that intuitive behavior control has an impact on consumers' participation in recycling. Therefore, government organizations shall invest more in recycling facilities and marketing strategies to provide a better recycling experience.

6.4. Economic incentive by points subsidy

Consumers generally have a high awareness of environmental protection, and most consumers are willing to pay higher prices for environmental protection products than ordinary goods. The government can provide economic incentives in the form of points subsidies, such as financial subsidies for purchasing environmental protection products that meet the standards, and subsidies that benefit consumers who purchase, use and recycle green products. In addition, more innovative approaches can be used to encourage consumers to purchase environment-friendly products for points redemption. A small number of GEN consumers who are less willing to accept the points system actually have potential environmental protection attributes in the context of the points system. For this group of consumers who pay more attention to economic returns, points redemption mechanism with promised financial returns would be more attractive. The government could use the anchoring effect (Tversky and Kahneman, 1982) and promote the economic benefits of the points system recycling policy, which will help encourage public participation in the e-waste recycling.

6.5. Promote environmental protection as a public value

The public is more willing to pay a price premium for environmental protection products, which have a positive public image and are in line with social values. The government and relevant organizations can promote environmental protection as an important public value, which will likely promote consumers' environmental awareness and behaviors.

7. Conclusions

This paper uses a survey method to evaluate how the introduction of a points system influences consumer types and their willingness to participate in e-waste recycling. Consumers have a strong sense of environmental protection, in order to make the points system smoothly and properly implemented. Based on results of two questionnaire surveys conducted in year 2016 and 2018, respondents were categorized into several consumer types, including GEN, ENV, ECO and EEF through cluster analysis. The results show that exposure to the idea of a points system can not only transform GEN consumers into consumers with obvious preferences, but also greatly enhance consumer environmental awareness. The analysis results also show that exposure to the idea of the points system can enhance consumers' awareness of recycling, which positively affect consumers' willingness to recycle e-waste. Finally, through variance analysis, results show that responses from different consumers types differ significantly on factors influencing e-waste recycling behaviors.

This research builds upon the TPB literature (Wang et al., 2016; Zhang et al., 2016; and Ylä-Mella et al., 2015), and uses empirical survey data to understand how consumer types can change when exposed to new knowledge of a points system for e-waste recycling. The findings of this paper indicate the consumers' environmental awareness and perceptions about e-waste recycle are responsive to incentive mechanisms such as the points system. This has important policy implications for the practical design of the points system. Theoretically, this paper fills in the research gap by providing empirical evidence on consumers' types and their preferences for e-waste recycling points system design in the context of China, one of the largest developing countries and generators of e-waste in the world.

However, due to the limitations of the questionnaire survey, the consumer type differences before and after the introduction of the points system are only supported by data, and the analysis of influencing factors of consumer types needs to be further refined. Also, this paper introduces weights to obtain the macroscopic change trend of respondents' environmental friendliness scores and the weights are not completely linear. In the future, the weights can be more accurately determined through expert participation, which can provide more specific and operable suggestions for the implementation of recycling points system. Another limitation of this research is that we do not use econometric methods to analyze data and to understand the causal mechanisms related to consumer perceptions and behaviors. In the future, econometric techniques such as propensity score matching and difference-in-differences models can be used to quantify the impact of exposure to the knowledge of the points system on consumers' attitudes and preferences for e-waste recycling. Lastly, future research design may use follow-up surveys to understand the temporal trends in consumer types and preferences on e-waste recycling by focusing on the same sample population.

Funding

This research was supported by The National Social Science Fund of China (No. 17BGL140).

Declaration of competing interest

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

Data availability

Data will be made available on request.

Appendix J. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clrc.2022.100087.

Appendix I. Question numbers in the two surveys

Question number in the first survey	Question number in the second survey	Question Description	Measurement Level
Q1	Q31	I think e-waste recycling is good for the environment.	Nominal
Q2	Q32	I think participating in recycling can contribute to environmental protection and bring me pleasure and a sense of achievement.	Nominal
Q14	Q33	I am more concerned about the recycling price of e-waste.	Scale
Q15	Q34	I care a lot about whether participating in recycling can improve my environmental image.	Scale
Q9,Q10,Q11	Q37	The convenience of recycling will affect my participation in recycling.	Nominal
Q12	Q38	The privacy of e-waste will affect my participation in recycling.	Nominal
Q5	Q39	I am willing to take part in e-waste recycling if my relatives and friends take part.	Nominal
Q7	Q40	Publicity from the government and environmental protection organizations will encourage me to participate in recycling.	Nominal
Q21	Q41	Are you willing to take the initiative to participate in e-waste recycling with the implementation of points system in the future? (0-very unwilling, 10- very willing)	Scale
Q22	Q42	I am familiar with the credit system.	Nominal
Q23	Q43	I am willing to participate in points activities.	Nominal
Q27	Q44	I am more concerned about whether the collected points have economic value such as whether they can be directly offset.	Scale
Q28	Q45	I am more concerned about whether recycling points can improve my environmental image.	Scale
Q36	Q53_ 1	Points redemption preferences:(Return cash)	Nominal
	Q53_ 2	Points redemption preferences: (Commodity exchange)	Nominal
	Q53_ 3	Points redemption preferences: (Exchange service: home appliance repair, cleaning etc.)	Nominal
	Q53_ 4	Points redemption preferences:(Green product discount)	Nominal
	Q53_5	Points redemption preferences:(Points activities)	Nominal
Q41	Q54	Are you willing to take the initiative to participate in e-waste recycling with the implementation of points system in the future? (0-very unwilling, 10- very willing)	Scale
Q51	Q55	Gender	Nominal
Q52	Q56	Age	Ordinal
Q54	Q57	Personal Income	Ordinal
Q53	Q58	Education	Ordinal
Q55	Q59	Occupation	Nominal
Q56	Q60	Province	Nominal

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