



Understanding consumers' behavior intention of recycling mobile phone through formal channels in China: The effect of privacy concern

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ARTICLE INFO

Keywords:

e-waste
Formal recycling
Privacy concern
Urban mining
China

ABSTRACT

The aim of this paper is to explore consumers' intention of recycling obsolete mobile phone through formal channels in China. Taking Jiangsu Province as an example, the survey results revealed that although nearly half of consumers prefer to save their obsoleted mobile phones at residence, those who are willing to participate in recycling prefer formal recycling channels instead of informal ones. To explore the determinants of formal recycling intention from the perspective of consumers' psychological characteristics, an integrative model based on the theory of planned behavior was established, in which the effect of consumers' privacy concern was thoroughly explored. The results indicated that recycling attitude, subjective norm, perceived behavioral control, and moral norm are all positively influential factors. Inconsistent with prior studies, consumers' privacy concern is found to have a direct positive rather than a negative effect on formal recycling intention. It also has a negative moderating effect on the relationship between subjective norm and formal recycling intention. Therefore, to promote consumers' formal recycling behavior of obsolete mobile phones, a series of measures are proposed to influence these psychological factors in the model. First, a positive social atmosphere for participation in formal recycling should be vigorously created. Then, further efforts are required to increase the publicity and availability of formal recycling channels. Furthermore, joint efforts should be made for privacy information protection during formal recycling processes, including establishing certification standards for secure data erasure, further routinizing recycling processes and establishing a credible image to obtain consumers' trust by formal recycling enterprises, etc.

1. Introduction

Nowadays, e-waste has become one of the largest and fastest growing wastes in the world (Guo et al., 2015; Wei and Liu, 2012). Of all kinds, obsolete mobile phone is the most ubiquitous electronic product (Guo and Yan, 2017). Mobile phone penetration rate in China reached 120.36% in 2019 (ITU (International Telecommunication Union), 2019). The rapid advance in technology drives the simultaneous improvement in the functions of mobile phone and the drop in price. As a result, consumers replace their phones more frequently. According to PDO (People's Daily Online) (2020), the stock of obsolete mobile phones in China is about 2 billion till 2019, with the recycling rate as low as 2%. Compared with other municipal waste, used mobile phones contain many harmful substances, such as lead, cadmium, and other chemicals which would severely pollute the environment and harm human health if not handled properly. At the same time, used mobile phones contain many valuable materials such as gold, silver, copper, etc. which can be recycled (Liu et al., 2019).

To this end, the effective recycling of obsolete mobile phones is imperative, among which one of the most pressing questions is how to collect and recycle them from consumers. Currently, there are four major channels for recycling mobile phone in China (Fig. 1), which are summarized as follows.

(1) Manufacturers recycling. Manufacturers such as Huawei and Apple provide recycling service for consumers to deal with their unused mobile phones. Consumers can bring back their old mobile phones to nearby stores or through internet platforms of manufacturers to get new-purchase discounts through programs such as "old for new". Notably, some manufactures such as Huawei also establish cooperative relations with third-party recyclers and increase the efficiency of mobile phone recovery.

(2) Certified processors recycling. There are now 109 certified e-waste recycling enterprises which are included in the list of subsidies for the treatment of e-waste. They can meet specific standards to safely recycle and manage electronics. Some of these enterprises have

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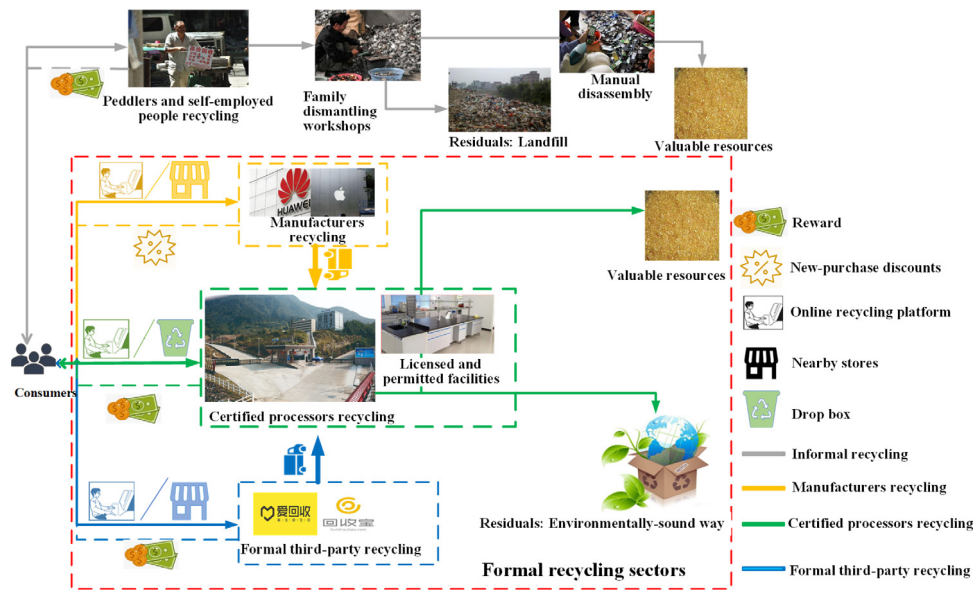


Fig. 1. Four recycling channels of obsolete mobile phone in China.

also developed a well recycling system by the combination of online and offline recycling service (Zhang et al., 2019a). Ala Huanbao, for example, not only places intelligent recycling boxes in the residential communities, but also establishes an online recycling platform. Consumers can get reward points to exchange products by participating in the recycling activities.

(3) Formal third-party recycling. Formal third-party recyclers work as the intermediary between consumers (source of e-waste) and recipient of recycled items to recycle e-waste properly. Among them, Aihuishou is the most vigorous one, which now operates more than 700 stores in China. Consumers can submit recycling orders through Aihuishou platform and have their obsolete mobile phones picked up at home, or visit drop box at a shopping center or communities to have their phones evaluated and receive an immediate reward. Based on a survey of NBD (National Business Daily) (2020), Aihuishou has recovered over 20 million sets of obsolete mobile phones in 2019.

(4) Peddlers and Self-employed people recycling. They often ride bikes or small trucks around communities or residential areas to purchase various kinds of obsolete electronic products from consumers and then sell them to small recycling enterprises or family dismantling workshops.

Among above-mentioned major approaches, the first three ones are deemed as formal recycling channel, which refers to licensed and permitted facilities that process e-waste in an environmentally-sound way. The fourth channel belongs to informal recycling, which is characterized by small-scale and unregulated work, substandard processes, and absence of the appropriate facilities to safeguard human health and the environment. However, compared with formal recycling, the informal one has an advantage in relatively higher payment and the flexibility of collection when other recycling ways were unavailable or inconvenient. Therefore, informal recycling used to be the prevalent e-waste recycling practice in China (Chi et al., 2011).

In recent years, formal recycling channels have flourished in China. Especially with the rapid development of the Internet, online recycling platforms have become more and more popular. According to a survey from Bai et al. (2018), consumers are aware of at least one formal recycling channel (including internet recycling platforms and recycling boxes), and the availability of formal recycling facilities is greatly improved. Then, how are different disposal methods preferred by consumers nowadays? What are the factors influencing consumers' intention to formally recycle their obsolete mobile phones? Such questions remain unclear.

As one of the most important taches of e-waste recycling, consumers recycling behaviors (and their influential factors) have drawn much attention (Islam et al., 2020). For China, consumers' recycling awareness and behaviors of obsolete mobile phones have also been explored. For example, Yin et al. (2014) investigated consumers' willingness to pay (WTP) for recycling mobile phones and further explored the influence of demographics (region, education level, and monthly income) on WTP. Bai et al. (2018) carried out a national survey on consumers' attitude and behavior toward smartphone recycling, and one of the focus is to investigate the external factors influencing mobile phone recycling in terms of recycling channels, including information security, reward, convenience, etc. Tan et al. (2018) found that the convenience of collection facilities and guarantee of information security would accelerate the collected amount of obsolete mobile phones. By conducting an online survey in university, Li et al. (2012) found the incentives with cash or voucher would be the efficient take-back approach. However, all these studies did not differentiate between formal and informal recycling channels. Besides, the psychological determinants of consumers' recycling intentions through formal channels are not paid enough attention. Especially, the effect of consumers' privacy concern, which may make a difference on formal recycling intention, has not been thoroughly explored (which will be discussed in the following section).

Regarding to the recent progress in formal recycling channels in China, the present study conducts a latest survey to investigate consumers' mobile phone recycling behaviors, and then the psychological determinants of recycling intention are explored, in which the effect of consumers' privacy concern is verified. The remainder of the research is constructed as follows. In Section 2, the conceptual framework and related hypotheses for the research are introduced. The research methods are outlined in Section 3. Section 4 focuses on results and implications. In Section 5, conclusions are drawn. The results will provide valuable suggestions to improve the collection rate of mobile phones in China.

2. Theoretical framework and hypotheses

The determinants of consumers' e-waste recycling behavior/intention can be divided into three major categories, namely external variables, internal variables, and demographic characteristics (Klöckner, 2013; Steg and Vlek, 2009). Many researchers assumed that individual decisions are based on a specific definition of rational self-interest and reward, then penalizing or regulating behavior can solve the recycling related problems (Chan and Bishop, 2013; Saphores

et al., 2012). On the other hand, some research showed that external incentives can only be effective in the short term (Carrus et al., 2008). In response, researchers also explored ways to increase long-term commitment to recycling behavior based on the psychological variables, such as attitude, belief, and moral norm. It is recognized that these variables are significant in stimulating individuals' recycling behaviors (Jekria and Daud, 2016; Wang et al., 2018a,b). Different theories and models have been proposed to analyze the relationship between psychological variables and recycling behavior, among which nearly 40% of all studies published in environmental psychology used the theory of planned behavior (TPB) as the theoretical framework (Klößner, 2013).

2.1. The theory of planned behavior

TPB was proposed by Ajzen in 1991 to predict and explain human behavior (Ajzen, 1991). TPB suggests that individuals' behavior is directly determined by intentions, and intentions are predicted by behavioral attitude, subjective norm, and perceived behavioral control. Behavioral attitude refers to an individual's positive or negative attitude towards a specific behavior. More positive the attitude toward the behavior of an individual, the more individual will be likely to perform a specific behavior. Subjective norm refers to the perceived social pressure from other individual or groups to perform or not perform a certain behavior. This pressure may come from family, peers, the neighborhoods, or anyone who are important to the individual person. If individuals think that the people closest to them want them to conduct the specific behavior, they are more likely to do so. Perceived behavioral control relates to the perceived ease or difficulty of performing the behavior and it reflects past experiences, anticipated impediments, and obstacles (Muniandy and Anuar, 2020). If individuals think that they have the ability or resource to perform the behavior, they are more likely to perform the behavior.

As discussed above, many researchers use TPB as the theoretical framework to explore recycling behaviors. The results from Kumar (2019) showed that the key influencing factors that influenced e-waste recycling behavior amongst young adults were attitude, perceived behavioral control and subjective norm. Lizin et al. (2017) has demonstrated that attitude and perceived behavioral control were important explanatory variables of used batteries recycling behavior. Echegaray (2016) found that attitude, subjective norm, and perceived behavioral control were all significant and positively related to consumer recycling intention in the major metropolitan areas of Brazil. By investigating Chinese residents from China's seven geographic regions and 22 provinces, Wang et al. (2016) found that the main factors affecting Chinese residents' e-waste recycling behavioral intentions were environmental awareness and attitude towards recycling.

Based on the above analysis, the following hypotheses are proposed:

H1: Attitude has a positive effect on consumers' intention to participate in formal recycling of obsolete mobile phone

H2: Subjective norm has a positive effect on consumers' intention to participate in formal recycling of obsolete mobile phone

H3: Perceived behavioral control has a positive effect on consumers' intention to participate in formal recycling of obsolete mobile phone

2.2. Moral norm

Despite the sufficiency of the TPB in predicting intentions and behaviors, the theory is in principle open to the inclusion of additional explanatory variables, if they can be shown to have a significant and distinct contribution (Ajzen, 2011). Thus, researchers have tried to incorporate additional predictors to increase the predictive ability of the model (Botetzagias et al., 2015). Among the different additional predictors, moral norm holds a special place. Moral norm is the core factor in norm activation model (NAM) proposed by Schwartz (1977), which refers to a feeling of moral obligation that motivates individuals

to engage in a particular behavior. Moral norm is conceptually different from subjective norm as it reflects self-expectations and personal responsibility for performing a given behavior (Manstead, 2000). A wide range of studies focused on the role of moral norm underlying pro-environmental behavior. For example, Lizin et al. (2017) used an integrative model based on the TPB to investigate the drivers and barriers of Belgian households' battery pack drop-off intention, and the result showed moral norm had the largest influence on the intention to drop-off used battery packs. Tonglet et al. (2004) observed the recycling behavior of 258 Brixworth households and found the moral norm was significantly correlated with recycling intention. The empirical results from Bamberg et al. (2007) showed that moral norm, as an additional predictor, increased the variance to explain pro-environmental behavioral intention.

Based on the above analysis, it is reasonable to assume that people's high degree of responsibility and moral obligation towards the environment will stimulate formal recycling of obsolete mobile phone; while not engaging in formal recycling will be contrary to their personal morality and social responsibility, which may make them feel guilty and uncomfortable. Thus, it is proposed that:

H4: Moral norm has a positive effect on consumers' intention to participate in formal recycling of obsolete mobile phone

2.3. Privacy concern

Besides making phone calls, nearly all mobile phones today can provide directions through GPS, take pictures, keep track of appointments and contacts, and support a series of internet activities (such as online shopping and payment). In this regard, they hold some of our most sensitive, personal privacy (like our emails, text messages, photos, videos, and account passwords, etc.). As a result, worrying about privacy information leakage may influence people's decision on their further disposal of obsolete mobile phones. As shown in Table 1, terms such as "privacy protection", "information security", "risk perception", "privacy risk", and "data protection/security" have been used to describe the privacy issue in e-waste disposal. However, much research just investigated this issue in a qualitative way, and consistent conclusions for the impact of these variables have not been achieved. Besides, these studies did not differentiate between formal and informal recycling channels.

Privacy concern measures individuals' concerns about organizational information privacy practices with four subscales: collection, errors, improper access, and unauthorized secondary use (Smith et al., 1996), and is often used to explore concerns across different Internet/mobile usage context (Anic et al., 2019; Bansal et al., 2010; Menard and Bott, 2020). For the practice of obsolete mobile phone disposal, privacy concern specifically addresses consumers' level of concern over the possible leakage of privacy and the unauthorized use of personal information stored in the mobile phone during the disposal process. That is, the construct is used in this research to express consumers' personal perception level on privacy misuse or leakage. As can be seen, it remains unclear whether and how consumers' privacy concern can take effect on formal recycling intentions. Therefore, the following hypotheses are given:

H5: Privacy concern will negatively affect consumers' intention to participate in formal recycling of obsolete mobile phone

H6: Privacy concern will moderate the relationship between recycling attitude (6a), subjective norm (6b), perceived behavioral control (6c), moral norm (6d) and formal recycling intentions

Based on the above analysis, the research framework is depicted in Fig. 2.

Table 1
Conceptions related to privacy concern.

Reference	Variable and definition	Analysis method	Hypothetical type of effect	Related findings
Liu et al. (2019)	Information leakage, No definition	Qualitative survey	None	Information leakage posed the greatest obstacle to mobile phone recycling, resulting in 30.45% of mobile phones being stored at home.
Li et al. (2012)	Privacy protection, No definition	Qualitative survey	None	The common reason for stockpiling obsolete mobile phones is respondents' awareness of privacy protection.
Bai et al. (2018)	Information security, No definition	Qualitative survey	None	Information security was chosen by the respondents as the most influencing factor on the decision of phone recycling.
Arain et al. (2020)	Data security, No definition	Qualitative survey	None	Reasons for e-waste storage include a lack of knowledge among consumers regarding disposal options, such as concerns regarding personal data security
Casey et al. (2019)	Data protection, No definition	Qualitative survey	None	The participants described an emotional connection to forms of data stored on electrical equipment, and several of them described the importance of data protection
Zhang et al. (2019d)	Privacy protection refers to consumers' trust about whether recyclers will clean the data stored in their obsolete mobile phones.	Multinomial logistic regression analysis	Direct negative effect (verified)	Privacy protection has negative impact on the consumers' recycling intention.
Zhang et al. (2020)	Risk perception is individuals' subjective assessment of the smartphone's recycling safety, especially information security.	Structural equation model	Negative moderating effect (verified)	Risk perception moderated the relationships between conscientiousness and the TPB variables in such a way that these relationships will be weak for individuals high in risk perception.
Wang et al. (2017)	Privacy risk is one dimension of the perceived risk relevant to online recycling.	Structural equation model	Direct negative effect (rejected)	Privacy risk has no significant effect on the residents' willingness of participating in online recycling.

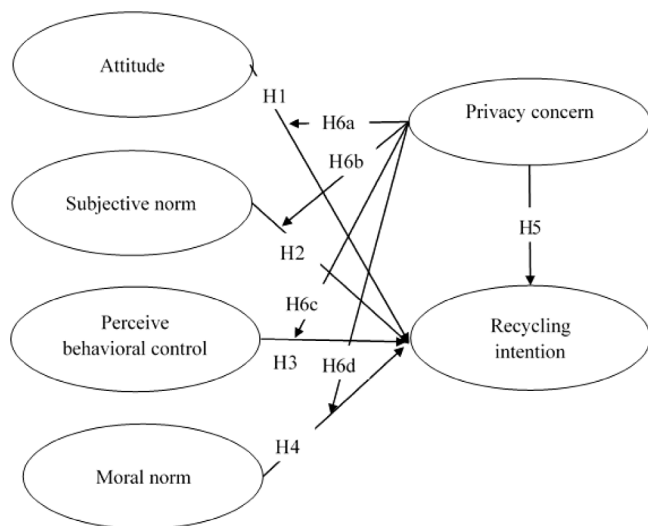


Fig. 2. The theoretical framework in this study.
Note: “recycling intention through formal channels” is named “formal recycling intention” here (the same as below).

3. Data and methods

3.1. Questionnaire design

To validate the conceptual model in Fig. 2, a questionnaire is designed and conducted. The main body of the questionnaire is divided into three parts. The first part focuses on consumers' preferences for disposal of obsolete mobile phones. Participants are asked to answer the question of “How did you dispose of your last obsolete mobile phone?”. The concept of “obsolete mobile phone” is clearly defined here. Obsolescence occurs when consumers decide not to use the mobile phone anymore (or rarely use it since then) owing to various reasons, so those obsolete phones may (or may not) have usable functions. The second part is designed to explore consumers' formal recycling intention towards obsolete mobile phones. So, it firstly defines the scope of formal/informal recycling channels, then focuses on the measurement of the constructs referred in Section 2. The final section of the questionnaire is about the basic information of the respondents, including gender, age, educational level, monthly income, and residential location.

All variables in the second part of the questionnaire are measured with multiple items (see Table S1). These items are based on a five-point Likert scale, where 1–5 stands for “strongly disagree”, “disagree”, “neutral”, “agree”, and “strongly agree”, respectively; and the higher the score, the more the respondents agree with the item. Specifically,

privacy concern is measured by items that are directly taken from the measurement of concern for information privacy outlined in Smith et al. (1996), with wordings adapted to capture perceptions of a specific mobile phone disposal privacy practice.

3.2. Sampling and data collection

Jiangsu Province was chosen as the case area for this research for two reasons. First, Jiangsu Province is one of the most economically developed regions in China. In 2019, the province ranked the second place in terms of the GDP in China, and took up 10% of China's total. Second, the ownership rate of mobile phone in this region is 2.48 per household, which is also at the head of all provinces in China. It can be reasonably foreseen that the amount of obsolete mobile phones in Jiangsu is considerable and deserves particular attention.

Mostly based on economic development level, the province is officially divided into three sub-regions: Southern Jiangsu (including Wuxi, Suzhou, Nanjing, and Changzhou), Middle Jiangsu (including Zhenjiang, Yangzhou, Nantong, and Taizhou) and Northern Jiangsu (including Xuzhou, Yancheng, Huai'an, Lianyungang, and Suqian). According to Kumar et al. (2017), consumers' recycling behavior was directly related to the level of the region's economic development, so stratified random sampling was used based on sub-regions division in the survey. The survey was conducted from mid-July to mid-August of 2020. Two survey methods were used: face-to-face method and online method. Face to face interviews can maximize the quality of the data collected as interviewers can provide guidance to the respondents and motivate them to finish the survey more carefully and thoroughly (Liu, 2017). However, due to the outbreak of the Novel Coronavirus Epidemic, face to face surveys cannot be carried out at a large scale. Therefore, an online questionnaire survey was also conducted as necessary supplements, which was done through a professional Chinese survey platform Survey Star.

In total, 681 questionnaires were obtained and 596 valid questionnaires were kept, resulting in an effective response rate of 87.5%. Table 2 shows the demographic information of participants. As shown in the table, the gender distribution of the sampled population is relatively balanced, with males and females having very close shares. Two age groups, 22–30 years and 31–45 years, take up approximately 80% of the total, which happen to be the active users of mobile phones. As for monthly income distribution, the largest proportion is 3001–8000 RMB, accounting for 49.8%, followed by 8001–15,000 RMB, accounting for 27.5%. Of the total participants in this survey, 55.4% holds a bachelor's degree. It is reasonable because as an economically developed region, the province can attract more people with high degrees. Besides, it also holds the largest number of universities and colleges among all provinces in China.

3.3. Data analysis method

To explore consumers' intention to participate in formal recycling of obsolete mobile phone, a hierarchical regression model was adopted using the SPSS 25 platform. The hierarchical regression is widely used in the TPB-based research to explain e-waste recycling behaviors (Razali et al., 2020; Tan et al., 2018; Wang et al., 2019; Zhang et al., 2019a). Before running the hierarchical regression, the residual analysis including independence test and normal distribution test are conducted. Then in the first regression, the control variables were included to test their influence. In the second regression, the three TPB variables including attitude, subjective norm and perceived behavioral control were added to test the main effect of the TPB framework. The extended variables (moral norm and privacy concern) were added in the third regression. Finally, the moderating effect of privacy concern was tested by adding the product of privacy concern and all other independent variables (TPB variables and moral norm), which generated four regression models (Model 4–Model 7).

Table 2
Demographic profile of respondents.

Demographic variables	Frequency	Percentage (%)
Gender		
Male	297	49.8
Female	299	50.2
Age		
18–21	32	5.4
22–30	304	51.0
31–40	165	27.7
41–50	81	13.6
51 and above	14	2.3
Education level		
Junior middle school or below	32	5.4
Senior high school	55	9.2
Junior college	137	23.0
Bachelor's degree	330	55.4
Master's degree or above	42	7.0
Monthly income (RMB)		
Under 3000	116	19.5
3001–8000	297	49.8
8001–15,000	164	27.5
15,001–20,000	15	2.5
20,000 or above	4	0.7
Location		
Northern Jiangsu	154	25.8
Middle Jiangsu	116	19.5
Southern Jiangsu	326	54.7

4. Results and discussion

4.1. Descriptive statistics analysis

The descriptive statistics analysis of the sample data is shown in Table 3. The mean score of formal recycling intention is 4.12 (SD = 0.69), which is above the neutral 3 and suggests that participants hold a positive intention towards recycling their mobile phones through formal channels. Of all other constructs, privacy concern has the highest mean score of 4.62, indicating that participants have severe concerns about privacy leakage and misuse during the mobile phone recycling process. The rest constructs have a mean score of 3.88–4.05, suggesting participants in our survey have a comparatively high level of recycling attitude, subjective norm, moral norm, and perceived behavioral control.

4.2. Reliability and validity test

According to Table 3, the Cronbach's alpha values for all variables are greater than 0.7, and the total scale's Cronbach's alpha is 0.918, demonstrating that internal reliability of the scale is acceptable. And then, validity test was conducted to ensure the effectiveness of the study, including the content validity, convergent validity, and discriminant validity. The contents of the questionnaire are based on the previous literature, thereby the content validity is deemed acceptable.

The value of KMO (0.926) and the significance level of Bartlett's test of sphericity (0.000) demonstrate that the original items are suitable for factor analysis. According to the result of factor analysis in Table 3, the corresponding factor loading of 20 items is above 0.5, and the CR values and AVE values clearly meet the requirements, thus the questionnaire has good convergence validity. As shown in Table 4, the square root of the AVE values is greater than the corresponding inter-construct correlations, suggesting acceptable discriminant validity (Chin et al., 1997). Therefore, the reliability and validity of the questionnaire are acceptable in this study.

Table 3
Descriptive statistics, and reliability and validity analysis.

Constructs	Items	Mean	S.D.	Factor loadings	Cronbach's alpha	Composite reliability (CR)	Average variance extracted (AVE)
Attitude	AT1	3.95	.861	.769	.825	.821	.605
	AT2	4.12	.750	.767			
	AT3	4.07	.894	.797			
Subjective norm	SN1	3.79	.953	.840	.880	.877	.641
	SN2	3.97	.899	.775			
	SN3	3.90	.903	.759			
	SN4	3.89	.942	.827			
Perceived behavioral control	PBC1	4.09	.766	.749	.861	.864	.616
	PBC2	3.96	.893	.825			
	PBC3	3.80	.981	.735			
	PBC4	3.84	.945	.826			
Moral norm	MN1	3.75	.990	.784	.761	.766	.621
	MN2	3.68	.995	.792			
Privacy concern	PC1	4.65	.652	.796	.873	.866	.619
	PC2	4.66	.629	.811			
	PC3	4.61	.681	.754			
	PC4	4.55	.705	.785			
Recycling intention	RI1	4.09	.828	.796	.823	.822	.607
	RI2	4.21	.747	.736			
	RI3	4.06	.833	.804			

Table 4
Pearson's correlation analysis.

	AT	SN	PBC	MN	PC	RI
AT	.777	.704***	.532***	.543***	.170***	.681***
SN		.801	.585***	.548***	.028***	.675***
PBC			.784	.398***	.118***	.632***
MN				.788	.036	.500***
PC					.786	.165***
RI						.779

Note: The square roots of AVE values are the bold elements in the diagonal; *** indicates $P < 0.01$, ** indicates $P < 0.05$, * indicates $P < 0.1$.

4.3. Correlation analysis

Before hierarchical regression analysis, Pearson's correlation analysis was conducted to evaluate the association between every two variables (Table 4). From the result of the correlation coefficient analysis, it is found that attitude, subjective norm, perceived behavioral control, moral norm, and privacy concern all have a significant positive correlation with recycling intention ($p < 0.01$). The correlation between moral norm and privacy concern is not significant, which needs to be further analyzed and verified through the following regression and moderating effects.

4.4. Consumers' preference for disposal of obsolete mobile phone

As shown in Fig. 3, approximately half of the respondents (49%) keep their last obsolete mobile phone at home, which is in accordance with a similar survey (Yin et al., 2014). The possible reasons are as follows. First, replaced mobile phones often hold economic and use value, so consumers may keep their old mobile phones as a sacrificial device (Wilson et al., 2017). Second, as much personal information is stored on the replaced mobile phone, consumers sometimes perceive it to be of some emotional value, and are more cautious about disposing of it for fear of privacy disclosure. Finally, it is convenient to keep the replaced mobile phone which takes up little house space.

25% of respondents recycled their obsolete mobile phones through formal recycling channels. Within the category the largest proportion comes from formal third-party recycling, accounting for 14%, followed by manufacturers recycling (9%). The remaining of respondents (2%) recycled their obsolete mobile phones through certified processors recycling. Compared with manufactures and certified processors, it seems that formal third-party recycling provides more convenient and comprehensive service at collecting consumers' obsolete mobile phones.

By contrast, informal collection only represents a tiny fraction of 2%, which suggests that consumers who are willing to recycle their obsolete mobile phones usually choose formal recycling channels. Fig. 4 shows a summary of consumers' preference between informal and formal recycling for handling obsolete mobile phones. It is indicated that with the prosperity of formal recycling channels and improved availability of collection infrastructure, consumers' preferences have changed in terms of recycling channels. Over the years, the formal recycling rate of obsolete mobile phones has been increasing. Additionally, compared with the whole nation and the central province of Henan, consumers in Jiangsu Province have a higher formal recycling rate, which may attribute to the higher level of economic development and more developed recycling infrastructure in this region.

4.5. Influence factors of consumers' formal recycling intention

Table 5 presents the results of hierarchical regression analysis. It can be seen the variance inflation factor (VIF) values in the collinear statistic are all less than 5, which is within the recommended threshold of 10.0 as suggested by Gebremariam et al. (2020), indicating that there is basically no multi-collinearity problem in the explanatory variables.

4.5.1. Model 1: demographic variables and formal recycling intention

The demographic variables are entered in the first step as control variables in model 1. Of all the demographic variables considered, only gender and monthly income have a significant impact on consumers' intention to participate in formal recycling. Female consumers are more likely to participate in formal recycling of obsolete mobile phone than male consumers (0 = female, 1 = male; $\beta = -0.124$, $p < 0.05$), which consists with the results by Saphores et al. (2012). Likewise, monthly income has a positive impact on formal recycling ($\beta = 0.1$, $p < 0.05$). That is, those with higher incomes are more likely to recycle their obsolete mobile phones. Similar results are found in households'

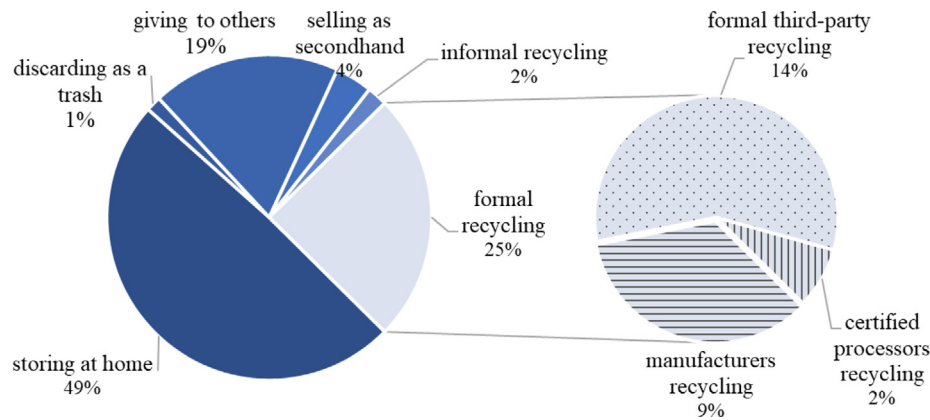


Fig. 3. Consumers' preference for disposal of obsolete mobile phones.

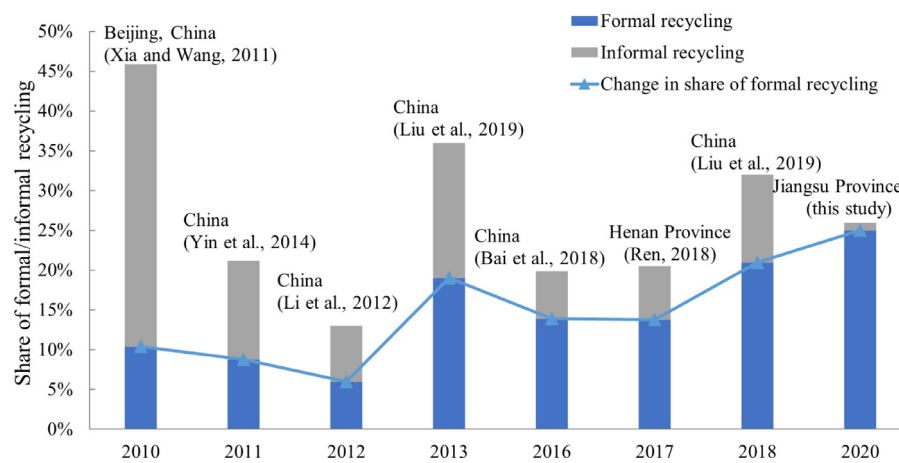


Fig. 4. Consumers' preference regarding the recycling channel of obsolete mobile phones.

Note: several studies do not differentiate between formal and informal channels. The disposal options of selling obsolete mobile phones to peddlers, private repair shops and second-hand markets in related research are classified as informal recycling in the figure; likewise, bringing back obsolete mobile phones to manufacturers and sellers, and recycling obsolete mobile phones through the “Green Box Program” are classified as formal recycling (Ren, 2018; Xia and Wang, 2011).

Table 5

Estimation results of consumers' formal recycling intention of mobile phone.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Co-linear statistics	
								Tolerance	VIF
Step 1: Control variables									
Gender	-.124**	-.062	-.066*	-.062*	-.066*	-.064*	-.066*	.884	1.132
Age	.045	-.013	-.018	-.019	-.018	-.019	-.018	.753	1.328
Education level	.014	.006	.001	.000	-.002	-.002	.001	.718	1.393
Monthly income (RMB)	.100**	.006	.011	.011	.014	.012	.011	.833	1.201
Location	.031	-.014	-.012	-.012	-.012	-.012	-.012	.859	1.164
Step 2: Independent variables (TPB variables)									
Attitude		.317***	.274***	.271***	.268***	.273***	.273***	.422	2.368
Subjective norm		.235***	.226***	.229***	.240***	.226***	.226***	.368	2.718
Perceived behavioral control		.273***	.260***	.261***	.257***	.263***	.260***	.598	1.673
Step 3: Independent variables (additional)									
Moral norm			.068***	.067***	.065***	.067***	.069***	.628	1.592
Privacy concern			.089***	.077**	.083**	.079**	.087***	.786	1.273
Step 4: Interactive effects									
Privacy concern * Attitude				-.041				.501	2.843
Privacy concern * Subjective norm					-.085**			.352	3.487
Privacy concern * Perceived behavioral control						-.051		.287	2.136
Privacy concern * Moral norm							-.015	.468	1.996
R ²	.024	.599	.608	.609	.611	.609	.608		
Adjusted R ²	.016	.593	.601	.602	.604	.602	.601		
ΔR ²	.024	.574	.010	.001	.003	.001	.000		
Sig.	.012	.000	.001	.259	.034	.186	.668		

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

source separation behavior (Alhassan et al., 2020) and e-waste disposal behavior (Milovantseva and Saphores, 2013).

4.5.2. Model 2: adding TPB variables based on model 1

Then three TPB variables are entered in the second step as model 2. It is clear that the value of R^2 increases significantly after adding the TPB variables ($\Delta R^2 = 0.574$). Recycling attitude ($\beta = 0.317$, $p < 0.01$), subjective norm ($\beta = 0.235$, $p < 0.01$), and perceived behavioral control ($\beta = 0.273$, $p < 0.01$) all have a significant positive impact on consumers' intention to participate in formal recycling, which is consistent with the previous studies on e-waste recycling behavior (Botetzagias et al., 2015; Yla-Mella et al., 2015; Wang et al., 2018c). Therefore, hypotheses H1 to H3 have been supported. From the results, we can also see that the recycling attitude is the most important factor for consumers to participate in formal recycling. This variable reflects consumers' favorability and awareness towards the importance of formal recycling. When consumers recognize that there are many benefits associated with formal recycling, the consumers will participate more positively in the activity.

The second influencing factor is perceived behavioral control. With the flourishing of formal recycling channels in Jiangsu Province, consumers can conveniently search for internet recycling platforms, or visit nearby stores to recycle their obsolete mobile phones, which has increased their enthusiasm to participate in formal recycling. Subjective norm is also influential in the prediction of formal recycling intention of obsolete mobile phone. In recent years, the region has made notable efforts in social promotion of e-waste recycling (e.g., widespread public service advertising), especially in urban areas, which has greatly improved consumers' intention to participate in formal recycling. This signifies a natural advantage of formal recycling channels over informal ones, i.e., support from the government and the whole society.

4.5.3. Model 3: adding variables of moral norm and privacy concern based on model 2

Then additional constructs of moral norm and privacy concern are added to the third model. It is indicated that the inclusion of new constructs in original TPB has improved the model fit. Moral norm ($\beta = 0.068$, $p < 0.01$) is significantly related to formal recycling intention, although it has a weaker association with consumers' formal recycling intention compared with subjective norm. This result is inconsistent with the findings of household waste sorting intentions, which found that personal norm is the major influencing factor (Zhang et al., 2019b). A possible reason is that different with household waste sorting, consumers tend to think it is the responsibility of the government or enterprises, rather than consumers, to take measures to deal with e-waste in a safe and environmentally responsible way.

The direct effect of privacy concern on consumers' formal recycling intention is also explored in Model 3. The results show that privacy concern has a significantly positive impact on consumers' intention to participate in formal recycling ($\beta = 0.089$, $p < 0.01$). The result seems opposed to our intuitive feelings (that is, privacy concern may become a barrier to effective recycling), as well as some previous findings which concluded that privacy protection has a significantly negative impact on individuals' willingness to recycle their mobile phones (Zhang et al., 2019d). The most likely explanation is that our research effort is focused on formal recycling channels, and people with higher privacy concerns are inclined to participate in formal recycling as they think it can protect their privacy in a much better way than informal recycling.

4.5.4. Model 4-7: testing the moderating effect of privacy concern

Before adding the interaction items to the hierarchical regression model, the independent and moderating variables are centered and the interactions of these variables are calculated. Model 4-Model 7 tests the moderating effect of privacy concern on the relationship between formal recycling intention and four antecedents. The results show that consumers' privacy concern has a negative moderating effect on the

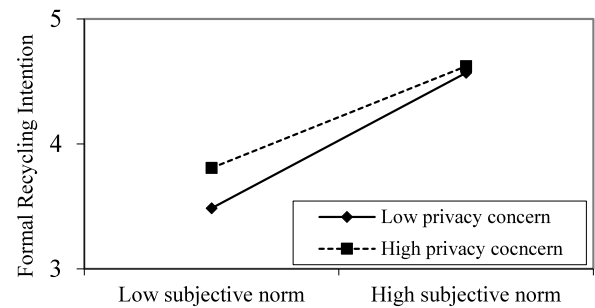


Fig. 5. Interactive effect of privacy concern and subjective norm on formal recycling intention.

link between subjective norm and recycling intention ($\beta = -0.085$, $p < 0.05$). That is, H6b is verified. Since the effect of independent variable (subjective norm) and moderating variable (privacy concern) on the dependent variable (formal recycling intention) is both positive, while the direction of the interaction item is negative, the pattern indicates an antagonistic interaction on formal recycling intentions.

To illustrate the privacy concern * subjective norm interaction with formal recycling intention, the regression of formal recycling intention on subjective norm at high (one standard deviation above the mean) and low (one standard deviation below the mean) levels of privacy concern is conducted. Fig. 5 indicates that the positive relationship between subjective norm and formal recycling intention is stronger for consumers who have low levels of privacy concern ($\beta = 0.691$, $p < 0.01$) than those who have high levels of privacy concern ($\beta = 0.5416$, $p < 0.01$). That is, among those who have high levels of privacy concern, the positive relationship between subjective norm and formal recycling intention would be weakened.

4.6. Practical implications

Based on verified hypotheses, several suggestions aiming to intervene model variables (i.e., individuals' psychological characteristics) by changing external situational factors of formal recycling, can be proposed to stimulate consumers' formal recycling behavior. Considering the effect of recycling attitude and subjective norm on consumers' formal recycling intention, the government should create a positive social atmosphere for participation in formal recycling through multiple media channels, such as local newspaper, subway advertising, and mobile popular social media platform of WeChat. The publicity content should emphasize the benefits of formal recycling, and provide detailed information on the proper ways to recycle waste phones.

Given the positive effect of moral norm on recycling intention, education can play an important role in enhancing this construct. On one hand, since the province holds a relatively large share of college students, it can make full use of advantage in higher education to help students develop a sense of moral responsibility towards mobile phone recycling. This is important because college students hold and obsolete more mobile phone than other residents (Zhang et al., 2019c). On the other hand, primary education (and even household education) can play a role in moral cultivation for medium-long term interventions.

As perceived behavioral control has a positive effect on consumers' formal recycling intention of obsolete mobile phone, further efforts are required to increase the availability of formal recycling channels. First, the spatial distribution of recycling facilities can be optimized considering regional disparities within Jiangsu Province. Second, formal recycling facilities have been concentrated in urban areas so far, and the construction of formal recycling infrastructure in rural areas is ignored. To further improve the formal recycling rate of obsolete mobile phones, the convenience of formal recycling channels in rural areas should be improved.

Finally, based on the direct and moderating effect of privacy concern, as well as an anticipated enhanced privacy concern of consumers in future, formal recycling channels should put more emphasis on the protection of consumers' privacy. On one hand, it is important to establish certification standards for secure data erasure (e.g., by the government or third-party organization), and regulate companies recycling processes according to these standards. On the other hand, formal recycling companies should try to consolidate their credible images by improving their publicity, opening their privacy protection policies and data erasure procedures, etc. These results on consumers' privacy concerns also indicate that it is important to accelerate formal recycling as it is much harder to regulate the behaviors of informal recycling companies and gain consumers' trust.

5. Conclusions and prospects

This study conducted a questionnaire-based survey to explore factors affecting consumers' formal recycling intentions of obsolete mobile phones in Jiangsu Province. The survey results revealed that 1/4 of total respondents chose to recycle their last obsolete phones through various formal collection channels. It is inspiring to find that the participation rate of formal recycling in Jiangsu Province is higher than that of the whole China, which may attribute to the development of various formal recycling channels and wide distribution of these collection channels in this region.

Analysis on the determinants of consumers' formal recycling intentions of mobile phone suggested that recycling attitude, perceived behavioral control, subjective norm, moral norm, and privacy concern all have a positive influence. The positive effect of privacy concern is surprising and interesting as it seems opposed to our intuitive feelings and previous findings, which signifies one of the important features of formal recycling channels, i.e., a relatively higher level of trust from consumers. Then, it is found that privacy concern negatively moderates the positive relationship between subjective norm and formal recycling intention. Based on the results, several suggestions are proposed to enhance consumers' participation in formal recycling of obsolete mobile phones.

From the theoretical perspective, the research demonstrates the effects of privacy concern on consumers' formal recycling intention, thus gives a more comprehensive understanding of formal recycling behavior. Despite the useful results and implications, several aspects need to be addressed in future. On one hand, the findings of the study in Jiangsu Province may or may not be generalized in other areas. It is necessary to verify the model in other regions or the whole China. On the other hand, we focused on the consumers' formal recycling intention of mobile phone instead of actual recycling behavior because behavioral intention can immediately determine the actual behavior (Ajzen, 2011). However, there is still a gap between behavioral intention and actual behavior (Muniandy and Anuar, 2020). Thus, to achieve a sustainable waste management (Awasthi et al., 2021; Birkin et al., 2021), the determinants of individuals' actual recycling behaviors should be further explored in future studies.

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.

Acknowledgments

The research was financially supported by the Natural Science Foundation of China (41971259), and the Humanities and Social Science Fund of the Ministry of Education in China (19YJCZH252).

Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.resenv.2021.100027>.

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