

Exploring Chinese consumers' attitude and behavior toward smartphone recycling

Hua Bai^{a,*}, Jing Wang^a, Amy Z. Zeng^b

^a School of Economics and Management, Beihang University, Beijing, PR China

^b Foies School of Business, Worcester Polytechnic Institute, Worcester, MA 01609, USA

ARTICLE INFO

Article history:

Received 1 February 2017

Received in revised form

14 January 2018

Accepted 24 March 2018

Available online 26 March 2018

Keywords:

Mobile phone recycling

Smartphone

Consumer behavior

WEEE

ABSTRACT

This paper aims to provide latest research results on consumer attitudes and behaviors about smartphone recycling. In particular, the study considers China as an example and reviews the country's recent progress in legislation and business practice in smartphone recycling. The study relies on a national survey to identify the patterns and trends in Chinese consumers' recycling attitudes and behaviors. Our results show that on top of incentive and convenience, information security is the number one requirement for consumers to recycle their smartphones. Additionally, although China has made significant progress in improving social environment and people's consciousness for phone recycling, more people still choose to store their waste smartphones at home. Moreover, the impact of recycling service on the sales of new phones is also discussed in the context of closed-loop supply chain design. As an exploratory attempt to understand smartphone recycling from the consumers' perspectives, this article presents critical factors influencing consumers' attitudes and behaviors in China, and sheds new lights on future academic research directions as well as on managerial applications and policy-making.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

Waste electrical and electronic equipment (WEEE, often referred to as E-waste) is one of the world's fastest growing solid wastes (Guo et al., 2015; Wei and Liu, 2012). Of all kinds, mobile phone is the most ubiquitous electronic product (Guo and Yan, 2017). By 2015, the number of worldwide cellphone subscribers has reached 7.1 billion (ITU Report, 2015). With the rapid development of network infrastructure and the growing popularity of smartphone, a mobile phone has exceeded its basic role as a communication tool and has gradually entered into every aspect of our lives. The fast penetration rate and upgrade speed are leading to an unneglectable amount of obsolete mobile phones in the world (Jang and Kim, 2010; Paiano et al., 2013). China has become the largest producer and consumer of mobile phones in the world since 2004 and the market has been growing continuously ever since. The average possession of mobile phone per inhabitant in 2025 is estimated to be two times higher than the average possession in 2010, leading to a total possession amount of mobile phones over 1.64 billion units in 2025. Moreover, 781 million units of obsolete

mobile phones were generated in 2015, and the number will grow to 877 and 937 million units in 2020 and 2025, respectively (Guo and Yan, 2017). Compared with traditional municipal waste, it is more complicated to dispose of obsolete mobile phones because they contain both the highly hazardous substances that impose environmental danger and the valuable metals that can be recovered and reused as substitutes for raw materials.

Since 2004, the importance of proper disposal of waste mobile phones has caught the attention of the academia, which was probably triggered by EU's introduction of E-waste Management Directive in 2002. The research endeavor has flourished and covered primarily five topics (Sarath et al., 2015): (1) the generation and management of mobile phone waste (Babatunde et al., 2014; Li et al., 2015; Polak and Drapalova, 2012; Rahmani et al., 2014); (2) consumer behavioral studies (Li et al., 2012; Nnorom et al., 2009; Ongondo and Williams, 2011; Welfens et al., 2013, 2016; Yin et al., 2014); (3) economics of mobile phone recycling (Yu et al., 2010); (4) toxicity assessment (Monteiro et al., 2007; Silveira et al., 2015), and (5) material identification and recovery (Silveira et al., 2015).

The small size of a mobile phone gives its owner a natural reason to store it at home when there is a lack of strong intention for recycling. This characteristic of mobile phone requires extra effort to motivate consumers to press the 'recycle button', because not

* Corresponding author.

E-mail address: hbai1115@163.com (H. Bai).

only “without proper consumer awareness, a recycling system cannot perform to its maximum efficiency” (Sarath et al., 2015), but also that enough consumer participation is the cornerstone of a successful mobile phone recycling system.

However, the recycle rate of mobile phones is only less than 10% on average globally (Welfens et al., 2013). It is recognized that understanding consumers' attitudes and behaviors regarding mobile phone consumption and recycling is a prerequisite for improving consumer participation in phone recycling effort. A number of studies using surveys have been conducted to unveil the factors influencing consumers' phone recycling behavior (Refer to Table 1). However, all of these studies are bit outdated as they were conducted several years ago and focused on mobile phones. The report from PEW Research Group shows that as of spring 2015, the average coverage of smartphones has reached 47% globally, and the coverage in specific countries can be much larger, e.g., South Korea 88%, Australia 77%, US 72%, Canada 67%, and China 58% (Fig. 1) (Global Attitude Survey, 2015). In China, the number of smartphones manufactured from January to November 2016 was 1.4 billion, accounting for 70.4% of the total volume of mobile phones manufactured during that period, with 12.7% increase from that in 2015 (MIIT, 2016). Smartphones have taken up over half of the market share of mobile phones and the coverage keeps increasing. Under such a circumstance, studying the attitudes and behaviors of smartphone owners about recycling will play an important role in any recycling initiative.

Moreover, the role of smartphones has greatly exceeded a communication tool and touched many aspects of people's daily lives, sometimes in the most private and delicate way. Will this change in the connection between the owner and the phone shift the influencing factors in consumers' mobile phone recycling decision? Previous studies have uncovered that recycle reward, awareness of recycling channels and convenience to recycle were the three most influential factors to consumers' recycle decisions (Aksen et al., 2009; Jang and Kim, 2010; Li et al., 2012; Ongondo and Williams, 2011; Welfens et al., 2016; Yin et al., 2014). Moreover, biased understanding of importance of mobile phone recycling can lead to low recycling rate (Baxter and Gram-Hanssen, 2016). However, no discussions on the impact of smartphones have existed in the literature.

As mobile phones were included in the category of WEEE for the Waste Electrical and Electronic Product Recycling Regulation (Chinese WEEE Directive) in 2014, more formal mobile phone recycling channels have emerged in the market ever since. The levels of awareness of recycling channels and convenience to recycle have been increased significantly in China. Thus, it makes sense to re-investigate consumers' smartphone recycling behaviors and concerns.

This research aims to bridge the gap by studying consumers' attitudes and behaviors toward smartphone recycling in the context of China and will present our latest research results derived

from a national survey. The paper is structured in the following way. Following the introduction in Section 1, Section 2 reviews the new changes under the grand picture of mobile phone recycling initiative in China from both the legislation and industry perspectives. In Section 3, the design and methodology of a national consumer survey is introduced. Section 4 and 5 present the survey results and detailed discussions of the latest trends in smartphone recycling from a consumers' perspective. Finally, we conclude the paper in Section 6 with practical implications and future research directions.

2. Background

2.1. Latest legislation on mobile phone recycling in China

Since 2001, the Chinese government has issued a series of laws and regulations to tackle the problems associated with the disposal and recycling of waste electrical and electronic equipment. The Ministry of Environmental Protection (MEP), the National Development and Reform Commission (NDRC), and the Ministry of Industry and Information Technology (MIIT) are the three main government agencies regulating WEEE management in China (Yang et al., 2008).

The Waste Electrical and Electronic Product Recycling Regulation, known as Chinese WEEE Directive, was released in 2009 and only five categories of products were included in the catalog back then, namely TV, refrigerator, washer, air conditioner and computer. It is until March 2016 that mobile phones were included in the latest WEEE Management Catalog and put into action (WEEE Catalog, 2014). This represents the first time in Chinese history that the proper management of mobile phone recycling was required and regulated by law. A mobile phone is under Item 13 of the catalog – mobile telecommunication handset. It is mandated that collected waste mobile phones be only processed by government certified WEEE recycling companies, and the mobile phone manufacturer and importer are required to pay a fee to the central WEEE management fund. This regulation not only reduces pollution risks from the loosely managed small recyclers, but also stimulates the manufacturers of mobile phones to complete the life cycle management of their products, and the development of 3rd-party recyclers.

2.2. Development of mobile phone recycling practice in China

There are two types of recycling programs for waste mobile phones in China: a voluntary program in which consumers turn in their waste mobile phones for free because of their social responsibility, and a reward based program in which consumers submit their phones to the recycler and receive a bonus (Wang et al., 2013).

The ‘Green Box Environmental Program’ and the ‘Green Card

Table 1
Survey research on consumer behavior of mobile phone recycling.

Name of Paper	Author(s)	Year of Survey
Electronic waste recovery in Finland: Consumers' perceptions towards recycling and re-use of mobile phones	(Ylä-Mella et al., 2015)	2013
Survey and analysis of consumers' behavior of waste mobile phone recycling in China.	(Yin et al., 2014)	2011
Collecting end-of-life mobile phones in Jakarta: A pilot	(Hanafi et al., 2013)	N/A
Consumer's Perception Regarding Recycling of Mobile Phones: A Prospective Assessment in the State of São Paulo, Brazil	(Koga et al., 2013)	N/A
Survey on Disposal Behavior and Awareness of Mobile Phones in Chinese University Students	(Li et al., 2012)	2012
Greening academia: use and disposal of mobile phones among university students	(Ongondo and Williams, 2011)	2008–2009
Survey of willingness of residents to participate in electronic waste recycling in Nigeria – A case study of mobile phone recycling	(Nnorom et al., 2009)	2007

Two-thirds worldwide use the internet, but fewer do in Africa and South Asia

Percent of adults who use the internet at least occasionally or report owning a smartphone

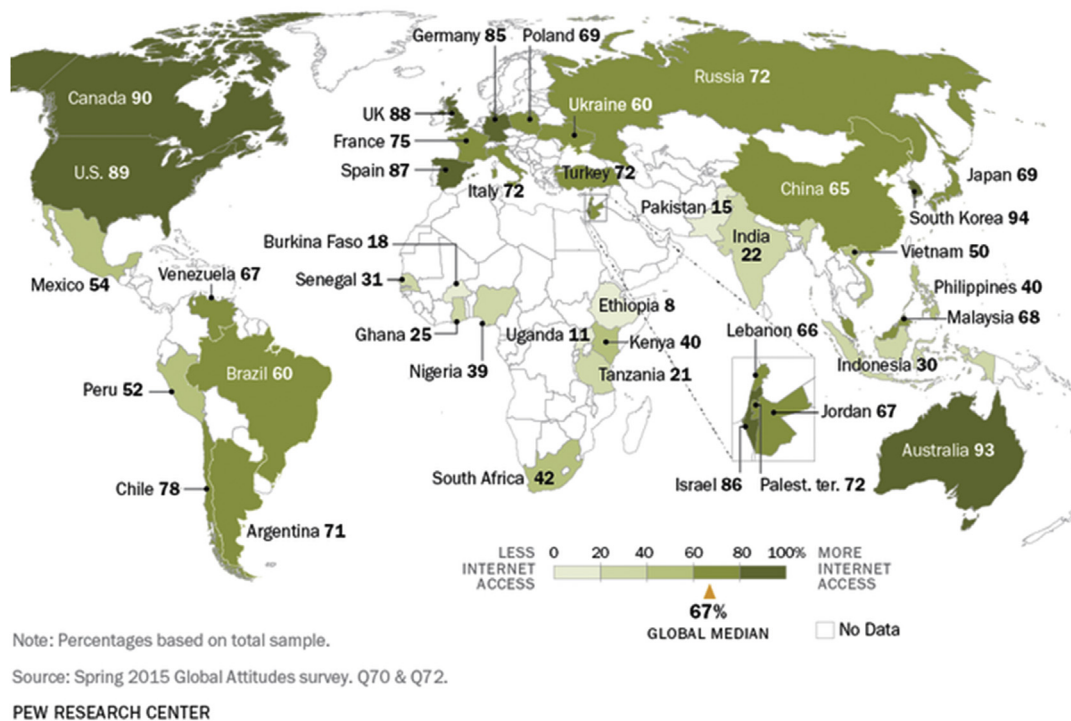


Fig. 1. Smartphone coverage in major countries in the world (Global Attitude Survey, 2015).

Recycling Activity' are two examples of voluntary recycling programs launched in China (Zhou and Xu, 2012). Such campaigns were meant to be conducted by leaders in the industry as part of their corporate responsibility program. However, the recycling rate was low and the programs were terminated after a short period due to the voluntary nature (Wang et al., 2011).

Four major channels exist in the reward based recycle program: by peddlers, by retailers, by specialized collectors and by second-hand market (Wang et al., 2011). Over the past two years, mobile phone recycling has become such a heated topic in China that more stakeholders actively participated in the recycling chain of waste mobile phones.

- **Manufacturer.** Apple Inc. has started its trade-in program in the US for several years and in 2016 this recycle program was introduced to China. By bringing back their old iPhones, consumers can receive a deduction from the price of the new iPhones they want to purchase. Domestic mobile phone manufacturers also launched various recycling programs; for example, Lenovo and Meizu, the two largest brands in consumer electronics and mobile phones, both posted their 'old for new' programs on their company website. Different from Apple Inc., they accept waste mobile phones of their own brand as well as others.
- **Retailer.** As one of the most famous online retailers, JD launched its recycling program for mobile phones in 2016. The tab of 'old for new' is listed at the top row of the mobile phone section on the company website. Additionally, the banner, 'in support of recycle service', is clearly marked right under the price section on the sales page of each mobile phone. By collaborating with a

3rd-party recycler, JD is able to manage and dispose of all e-waste responsibly. Consumers taking part in this program receives a coupon from JD, which can be used on any category of products sold on jd.com.

- **3rd-party recycler.** Over the past several years, a number of specialized recyclers have emerged in China with aihuishou being the most vigorous one. In 2016, aihuishou invested heavily in promoting its mobile phone recycling service; for example, they have placed advertising commercials on buses and subways in major cities. Additionally, aihuishou collects waste mobile phones both online and offline. Consumers can either make appointments on line and have their waste mobile phones picked up at home, or visit an aihuishou drop box at a shopping center to have their phones evaluated and receive a reward right away.

In summary, the fast development of the recycling industry in China provides more channels for consumers to recycle their end-of-life mobile phones and increase recycling convenience. The booming of the industry and the wide availability of recycling information has greatly improved consumers' awareness of e-waste recycling, and hence motivated the recycling activities in general.

3. Methodology and data collection

3.1. Questionnaire design

In order to investigate the development and the status of mobile phone consumption and disposal in China, as well as the attitudes and behaviors of the smartphone users towards recycling, we adopt

a survey approach to find answers. We aim to understand the attitudes and behaviors of Chinese consumers in smartphone consumption, from purchase, usage to disposal, as well as the effect of critical factors on recycling end-of-life smartphones. Our questionnaire consists of the following aspects:

- (1) Overview of mobile phone usage habits, including purchase preference (new vs. remanufactured), choice of purchase channels, reasons and cycles for replacement;
- (2) Attitudes and behaviors towards smartphone recycling, including acceptability of smartphone recycling, awareness of available recycle channels, barriers for recycling, influence of recycle service on new mobile phone purchase, choice between recycle reward and recycle convenience;
- (3) Awareness of mobile phone pollution, disposal responsibility and legal requirements, including their willingness to pay and payment method;
- (4) Influential factors on consumers' mobile phone recycling behaviors;
- (5) Demographic data.

3.2. Scope of survey and sampling methodology

The purpose of this research is to investigate Chinese consumers' attitudes and behaviors of mobile phone recycling in the era of smartphones on a national scale. The stratified random sampling method is adopted while the survey is conducted, aiming to present a well-rounded picture of characteristics of consumers from different regions of China (CBNweekly, City classification 2016, 2016).

Since consumers' recycling attitude and behavior are the results of a combination of multiple factors, we have used the widely accepted city classification system as a basis for the stratified random sampling, instead of classifying consumers simply by the per capita Gross Domestic Product (GDP). According to the city classification system in China, the cities are sorted into different tiers, according to several evaluation indicators including, but not limited to, per capital GDP, population, area, human development index, local fiscal revenue, number of Starbucks and KFCs, regional radiation power, political importance and others. The entire country is divided into 3 sub-regions: tier-one cities, tier-two cities, and tier-three and lower cities. For our survey, 5 tier-one cities, 21 tier-two cities and 45 tier-three and lower cities are included with 1/3 of samples coming from each sub-region.

3.3. Execution

Due to the broad geographical scope of this research, an online survey¹ tool <https://www.formtalk.net/> is used to distribute the questionnaire. The detailed survey process is described below.

First, the questionnaire was designed and a survey link was generated by the tool. Second, we sent the survey link to selected contacts in the target regions through WeChat (China's biggest and most frequently used social APP), who are all college professors. This step is a point-to-point process to make sure the samples cover all three sub-regions in China. Finally, the professors posted the survey link to two groups. One is to their Friend Circle in WeChat, whom were asked to not only answer the survey but to forward the survey link to their Friend Circles as well. The second group is the

Table 2

Demographic composition of the samples.

	N (number)	%
<i>Gender</i>		
Male	369	45%
Female	451	55%
<i>Age</i>		
Below 20	125	15.2%
20–25	303	37%
26–30	115	14%
31–40	176	21.5%
41–50	72	8.8%
Above 50	29	3.5%
<i>Monthly Disposable Income</i>		
0–1000 RMB	150	18.3%
1000–2000RMB	198	24.1%
2000–3000 RMB	132	16.1%
3000–4000 RMB	85	10.4%
4000–8000 RMB	119	14.5%
8000–15000 RMB	85	10.4%
Over 15000 RMB	51	6.2%
<i>Education Level</i>		
High School and Below	48	5.9%
Junior College and Bachelor	547	66.7%
Master	173	21.1%
Doctor	52	6.3%
<i>Region_1</i>		
First-tier Cities	306	39.5%
Second-tier Cities	254	32.8%
Third-tier Cities and Below	214	27.6%
<i>Region_2</i>		
North China	416	53.7%
South China	358	46.3%
Total	820	

students in their class(es). The students were asked to answer the survey and/or send the survey to their Friend Circles.

Before the final data gathering, a pilot survey was carried out in Nanjing, Jiangsu province, Chongqing, and Binzhou, Hunan province in June 2016. The results and feedback were collected and adjustments were made to finalize the questionnaire. Then the survey was distributed to consumers in the target provinces and cities. Data collected was analyzed using IBM SPSS Statistics 22.

4. Basic survey results

The survey responses were collected from June 2016 to December 2016. Based on the feedback from the online survey platform, a total of 3267 people participated in the survey and 821 people submitted complete questionnaires, out of which 820 were valid. The response rate was 25.13% and availability rate was 99.8%. The reasons for the low response rate might be that (1) online survey usually receives lower response rate than on-site survey in nature; (2) our questionnaire is rich in content and requires about 15–20 min to finish, hence a lot of participants may have given up half way; (3) some participants experienced problems at submission due to system errors, and hence their results were not recorded. The substantially high availability rate is due to the setup of the questionnaire, where each question must be answered before next one. The demographic composition of the respondents is presented in Table 2.

5. Discussions and implications

5.1. New trends in mobile phone consumption and recycling

5.1.1. Consumers' mobile phone consumption habits

- Mobile phone ownership

¹ The link for the questionnaire: <https://www.formtalk.net/pub.do?f=1BD2C8F924F29E1391450EAD75753388F12DDC1D84CF8735697058C98477B32>.

Table 3

Preference of different types of mobile phones from different purchase channels.

	N	Min	Max	Mean	S.D.
Brand new mobile phone from official channel	820	1	7	6.36	.984
New mobile phone from non-official channel	820	1	7	3.37	1.913
OEM Refurbished mobile phone	820	1	7	2.26	1.626
3 rd party refurbished mobile phone	820	1	7	1.68	1.223
2 nd hand mobile phone	820	1	7	2.15	1.524
Valid N	820				

Table 4

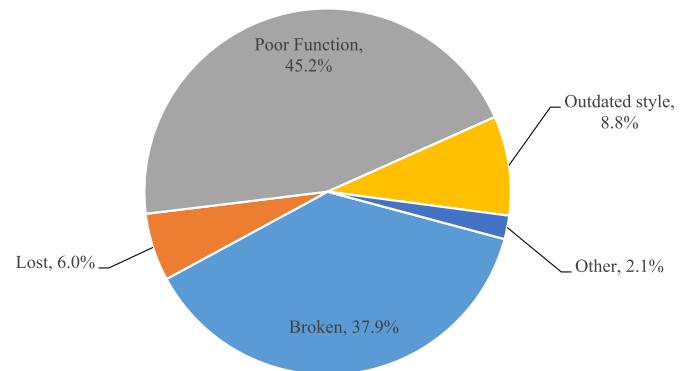
Service lifetime of mobile phones.

	N	Mean	S.D.	T-test between average and latest service time				
				T	df	significance	95% Confidence Interval	
							LB	UB
How long is the average service time of your mobile phone?	820	2.61	.773	96.504	819	.000	2.55	2.66
How long is the service time for your last mobile phone?	820	2.24	.928	69.086	819	.000	2.17	2.30

Out of the 820 valid respondents, over one third reported having more than two mobile phones active at the same time while the majority (2/3) owns one. Although we did not deliberately filter out smartphone users when distributing the questionnaire, more than 95% respondents were smartphone users, and this ratio is higher than the data reported by other institutions: 66% by Nielson ([mobile-consumer-report-february-2013](#), 2013) and 58% by Pew Research Center 2015 Spring (<http://mo.techweb.com.cn/2016-05-11/2330764.shtml>). There are three possible reasons for this difference: (1) our survey reflects the latest smartphone coverage ratio and is parallel to the increase of smartphone sales; (2) the distribution of our questionnaire is through online channels, and the Internet users are primarily smartphone users; and (3) the majority of our survey respondents have higher education, live in urban areas, and are below 50 years old, who are not typical feature phone holders. Although the samples might be biased from the general mobile phone holders group, they are the exact targets we want to study – smartphone holders and the main driving force for promoting recycling activities.

- Purchase channels and acceptance for remanufactured/second hand mobile phones

To investigate consumers' acceptance of different types of mobile phones from different channels, we have used a 7-point Likert scale, where the acceptance level ranges from extremely agree to extremely disagree. The consumers were asked to express their preference among the following five purchasing options: (1) brand-new mobile phone from official channels, (2) brand-new mobile phone from non-official channels, (3) OEM refurbished mobile phone, (4) third-party refurbished mobile phone, and (5) second-hand mobile phone. As the results in Table 3 indicate, with 4 point being neutral, only 'brand-new mobile phone from official channels' received very positive opinion and its average acceptance was rated between strongly agree to extremely agree. Among the other four not well accepted types, 'brand-new mobile phone from non-official channels' received higher score than 'OEM refurbished mobile phone', although only as low as 4.4% people indicated their willingness to purchase their phones from non-official channels. Even though a refurbished mobile phone can be purchased from the original manufacturer, it still cannot compete with brand-new one from an untrustworthy channel (non-official). On the other hand, 'second-hand mobile phone' is

**Fig. 2.** Reasons for replacing mobile phone.

better accepted than 'third-party refurbished mobile phone' that received the lowest score, suggesting that Chinese consumers have very low confidence in the concept of refurbishing and a third party.

- Life cycle of mobile phone

According to the survey data, the number of waste mobile phone stored at home was 1.79 per person. Moreover, people tend to upgrade their mobile phone quite often; in particular, while the average service time was 2.61 years, the average service time of their last mobile phone was even shorter - 2.24 years, and the trend of shortening service time was statistically significant ($p = 0.5$) (Table 4). On the other hand, compared with the survey results in 2011 (Yin et al., 2014), the number of people who reported upgrading their mobile phones every three years or longer dropped dramatically from 58% to 13.8%. In 2011, 43.8% of users in China would not replace their mobile phone until it is damaged (Yin et al., 2014). Today, however, as indicated in Fig. 2, the top reason for smartphone replacement is function upgrading, which is driven by the fast advent of technology, function and APP over the past several years.

5.1.2. Consumers' recycling behavior and attitude

According to the survey conducted in 2011 by Yin et al. (2014), 47.1% of waste mobile phones were stored at home; but we found

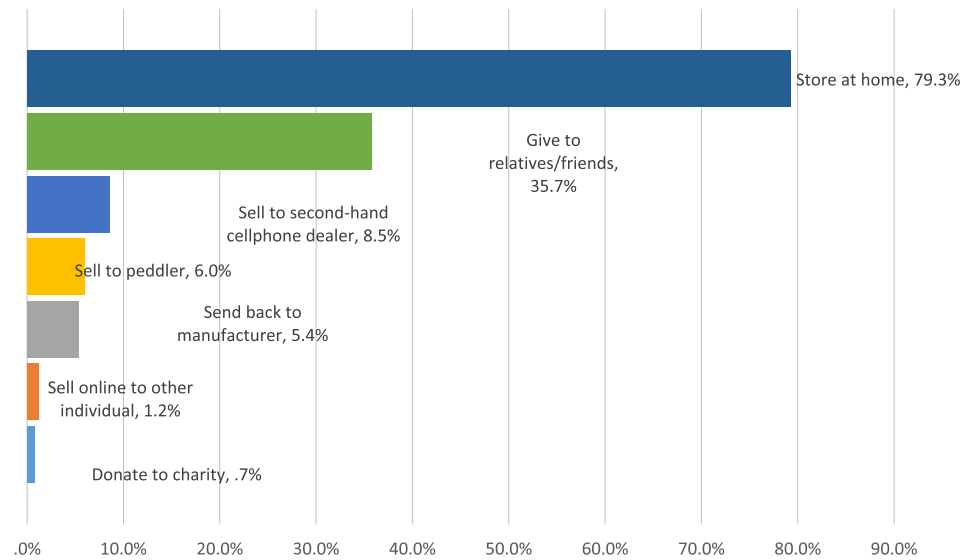


Fig. 3. Disposal methods of mobile phones.

Table 5
Willingness to recycle.

	N	Min	Max	Mean	S.D
Will you consider recycle the old one when update your mobile phone the next time?	820	1	5	2.78	.829
Valid N	820				

in our study that the percentage increased to 57.9%, which seems to suggest that consumers tend to be more conservative about giving out their used phones. In contrast to this trend, more recycling channels such as OEM recycling programs, various 3rd party recycling campaigns and the convenient online second-hand transaction platforms have emerged in the market in recent years. The existence of such channels has significantly reduced the number of used mobile phones sold to peddlers, from 12.4% to less than 4.4%. However, the overall recycling activity did not improve much, as 79.3% of consumers stored their waste mobile phones at home (Fig. 3). On a five-level Likert Scale with 1 meaning 'Will certainly not' and 5 meaning 'Will recycle', the average score was 2.78, which is below the neutral 3, for the question, "Will you recycle the old one when replacing your smartphone the next time?" (Table 5). The low score seems to suggest that Chinese consumers possess a rather negative attitude toward recycling their mobile phones.

With various recycling channels flourishing, the Chinese citizens are presented with a variety of recycling programs. Different from the past when the majority of people did not recycle their mobile phones due to low awareness of recycling channels, this survey shows that all respondents are knowledgeable about at least one recycling channel. However, the willingness to recycle is declining, which needs to be investigated.

5.2. Factors hindering the behavior of consumers in mobile phone recycling

Much different from the reasons suggested in 2011 (Yin et al., 2014) that most consumers (45.9%) did not recycle their mobile phones because they did not know any recycling channel and the recycle reward was too small (28.3%), our survey shows that each

respondent knew at least one channel to recycle their phones. However, 63.7% of consumers did not want to recycle because of the fear for personal information disclosure and of the low trust for the recycling parties. This is an important characteristic of smartphone recycling and a large concern of the smartphone users, whereas only 17.7% consumers had such a concern five years ago. Having a smartphone has utterly changed people's focus and consideration when deciding how to dispose of their used phones, as the phone carries their most personal and private information, and information leakage could be catastrophic.

Previous studies have also shown that recycling fee, convenience, payment period, charitable purpose, education and awareness level could all affect consumers recycle behavior. Taking into consideration of the new characteristic of smartphone users, we included information security into the list of influencing factors for the first time. Moreover, as shown in Table 6, information security was chosen by the respondents as the most influencing factor on the decision of phone recycling, followed by recycle price and recycle convenience. In the era of smartphones, the ability to gain consumers' trust in protecting their private information becomes the prerequisite for a successful phone recycling system. When asked about their preferred way for disposal of used phones, 5.1% of respondents were so concerned about information security that they would smash the phone into pieces before throwing it away. Among the 47.5% of people who wanted to find a way to extend the life of their used phones, 30.3% hoped to recycle through OEM or a certified 3rd-party recycler, and only 6.2% would just choose whoever offered the highest price.

Table 6
Influential factors of mobile phone recycling.

	N	Min	Max	Mean	S.D.
Information security	820	1	7	6.31	1.271
Recycle reward	820	1	7	5.46	1.290
Convenience	820	1	7	5.45	1.341
Timely payment	820	1	7	5.03	1.469
Non-profit Organization/Charity	820	1	7	4.92	1.349
Social education	820	1	7	4.82	1.376
Advertisement	820	1	7	4.42	1.398
Valid N	820				

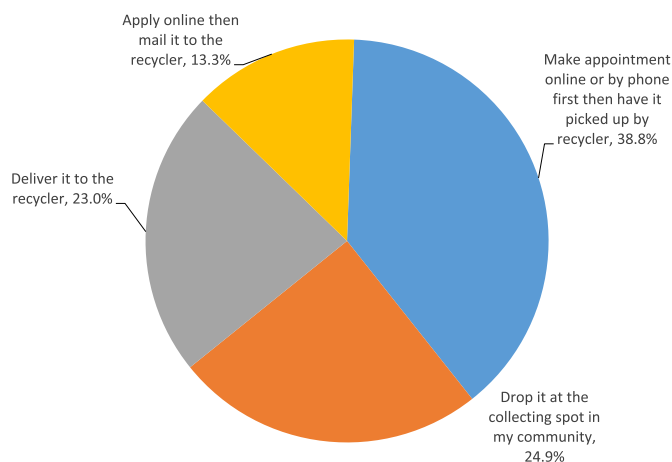


Fig. 4. Preferred recycling method for mobile phones.

5.3. Consumers' preferred ways for mobile phone recycling

Today's Chinese consumers are offered with more recycling channels than ever before, ranging from various recycling programs at brand stores to 3rd-party recycling campaigns, or from wide-spread drop-boxes in large shopping malls to on-site pick-up services. With the rapid development of e-Commerce in China, consumers are getting used to door-to-door service and have higher expectation for convenience. The preferred recycling pattern is shown in Fig. 4, where the choices are ranked by convenience level. Interestingly, despite of being the most convenient option, the door-to-door service was ranked low in 2011 (11.1%), because e-Commerce was not mature and consumers had low acceptance for on-site services a few years ago.

5.4. Consumers' consciousness for recovery

Awareness of the importance of mobile phone recycling from both the perspectives of environmental protection and resource conservation has a vital role in improving consumers' participation (Baxter and Gram-Hanssen, 2016). Respondents to our survey also identified 'weak environmental protection awareness' as the number one reason for the low recycle rate of mobile phones in China. According to Table 7, the awareness level of pollution risk from improper disposal of waste mobile phones and its value in resource conservation need to be improved for the Chinese consumers. Between the two concepts, consumers had general understanding of possible pollution consequences, if not thoroughly. However, the importance recycling on resource conservation was not well recognized. This lack of acknowledgement in resource efficiency led to the choice of 'do nothing' under the feeling that this action did not actively harm the environment and that the mobile phone owner was not being irresponsible (Baxter and

Gram-Hanssen, 2016). Whereas, the null option is far from environmentally neutral as shown in Fig. 5, which roughly to scale, spanned 90% along the spectrum of mobile phone disposal from responsible to irresponsible (Baxter et al., 2016).

5.5. Consumers' selection between convenience level and incentive level

Previous studies have pointed out that convenience and incentive are two important factors influencing consumers' recycling behavior. In our survey study, we considered four scenarios to investigate consumers' choices under different circumstances. For the four recycling methods offered, we change the convenience level based on the distance to the recycling site as follows: (1) home pick-up service (closest); (2) community recycle center (closer); (3) recycling stall at shopping center (far); (4) second-hand market in the suburb (farthest). The results are displayed in Fig. 6. In scenario 1, when all four recycling methods were offered with the same recycling price, almost 90% of people selected the two most convenient and closest recycling method: pick-up service (46.7%) and community recycle center (41.9%). In Scenarios 2, 3 and 4, where the reward level and the convenience level are inversely proportioned, many consumers gave up convenience to favor higher selling price of their phones.

In order to find out whether the consumers' attitudes and behaviors vary with respect to recycling high-end and low-end mobile phones, we looked at scenarios 3 and 4 further. In both scenarios, a high-end (5000 RMB) and a low-end (2000 RMB) mobile phones were to be recycled, and the recycle rewards were 1650 RMB, 1700 RMB, 1800 RMB and 1900 RMB/350 RMB, 400 RMB, 500 RMB and 600 RMB, respectively at different convenience levels. Interestingly, when recycling the expensive mobile phone, more people chose reward over convenience, whereas convenience was favored by the majority when recycling the low-end mobile phones. The counter-intuitive result shows that the recycling decision was independent of the difference between each option in the scenario, but was driven by the evaluation of total gain and loss from the option.

5.6. Influence of recycling service on mobile phone sales

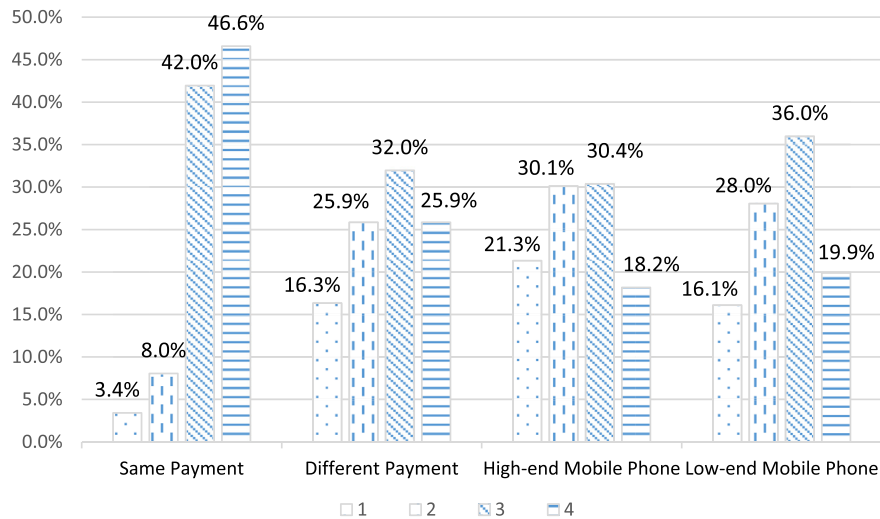
The data from our survey suggest that recycle service would have a positive impact on the sales of new mobile phones, as shown in Fig. 7. Whether the service was free, reward based or charged, more consumers stated that they would choose the seller with the recycle service over other sellers, than those who would not be affected by the service or were not sure. When the recycle service was reward based, as high as 65% people would choose the mobile phone seller with the recycle service over the vendors selling the same mobile phone but offering no recycle service. Even when the recycle service was to be charged, 48.2% consumers were willing to purchase their mobile phones at the service provider. Although 24.2% may not purchase the recycle service, the decision of which

Table 7
Understanding of pollution risks and resource conservation importance from mobile phone recycling.

	Criteria	Mean
Do you think it will cause pollution to dispose of old cellphone as household garbage?	1-No. It can be thrown away with other household garbage; 2-Maybe. Not sure; 3-Battery can cause pollution. Remaining parts of the phone can be thrown in household garbage; 4-Yes. Even without battery there are many pollutants in the phone and burial or burning can cause pollution.	3.245
Choose the right descriptions that you think correct about phone recycling.	1-For information security, used mobile phones should be disposed as household garbage after pollutants are taken out; 2-Reuse of functional cellphones should be realized through proper channel; 3-Reuse of functional parts should be encouraged; 4-Materials are better recycled when possible in order to reduce the use of raw materials	2.505



Fig. 5. Positioning of the null option on a scale of environmental impact relative to responsible (recycling) and irresponsible (municipal waste) disposal options for mobile phones. Based on life cycle assessment calculations in (Baxter et al., 2016).



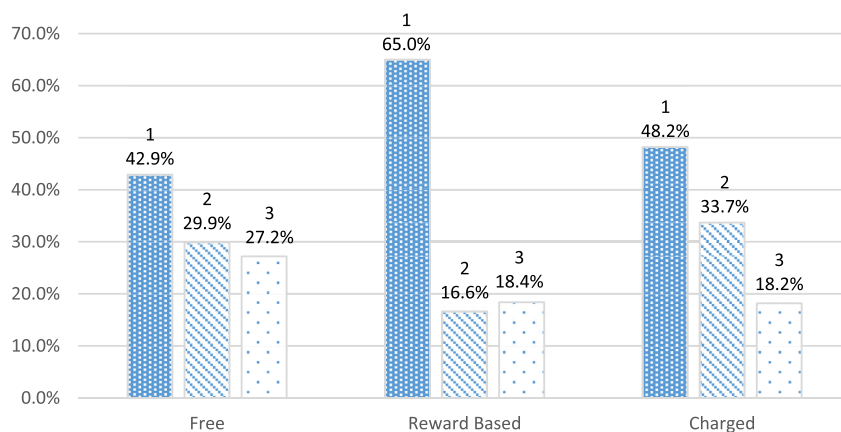
1. Sell it at a second-hand market (farthest)
2. Take it to the recycle site in a shopping center (far)
3. Drop the mobile phone at the recycling spot within your community (close)
4. Make appointment online or by phone first then have the phone picked up by recycler

Fig. 6. Choice between incentive and convenience under different circumstances.

was made based on the service price, they still chose to purchase their phones from the seller who provided the service. The recycle service affects not only the end-of-life mobile phones, but the sales of new mobile phones as well. Thus, providing recycle service may give advantage to the phone vendors in the competitive market.

6. Concluding remarks

This article aims at seeking answers to the following research questions: (1) What is the influence of popularization of smart-phones on consumers' phone recycling attitudes and behaviors? (2)



1. I will buy from the seller who offers recycle service.
2. Recycle service will not affect my choice of mobile phone seller.
3. I am not sure.

Fig. 7. Impact of recycle service on the sales of new mobile phones.

How has China been developing in the aspect of mobile phone recycling? and (3) Under current circumstance, what are the new trends of Chinese consumers on mobile phone recycling? Through a review of latest legislation and industry development and a national survey, we have arrived at the following implications:

- (1) The use of smartphone has utterly changed the priority of consumers' recycling decisions. In particular, information security is the most influential factor in the decision making process. Any party in the recycling industry that can gain the most trust from consumers has the biggest competitiveness in the market. Furthermore, to improve recycle rate of mobile phones and facilitate the benign development of the recycling industry, government involvement and endorsement are imperative and will direct uncertain consumers to trustworthy parties.
- (2) China has made significant progress in mobile phone recycling. With the first legislation on mobile phone recycling in place and prosperous development of recycling services from various parties, Chinese consumers' awareness of mobile phone recycling has been raised greatly.
- (3) Chinese consumers have developed higher expectation for recycling convenience due to the rapid growth of e-Commerce in China during the past several years. Door-to-door pickup service is accepted and welcomed by the majority of residents. Partnering with a logistics company and providing pickup service may motivate more consumers to recycle their home-stored old phones.
- (4) Recycle service not only affects the management of end-of-life mobile phones but also places positive effects on the sales of new mobile phones. Consumers are more willing to purchase from sellers who offer recycle service, no matter whether the service is free, reward based or charged. This important finding offers an opportunity for mobile phone vendors about how to improve their sales. For future research, recycle service fee should be included in the overall economic analysis of a mobile phone reverse supply chain.

As the first study aiming to understand the attitudes and behaviors of the smartphone owners regarding phone recycling, this article provides new insights on this pressing issue, as well as on managerial implications and policy-making in the context of China. Furthermore, this research presents the latest development of mobile phone recycling in China from the standpoints of both legislation and business practices. Through a comprehensive national survey, we have identified the critical factors influencing smartphone owners' recycling behavior and closed some of the gaps in this research field. Although the representativeness of the samples is controlled carefully in this research, the sample size is small compared with the population. Due to limitation of the survey approach and the relatively small size, we are able to acquire only some subjective intentions from the respondents in this study. For further research, we plan to integrate more behavioral data from utilizing other research methods and to obtain larger sample size to verify the findings presented in this study.

Acknowledgement

This work is supported by the National Natural Science Foundation of China (No. 71332003). We thank our contacts who helped to distribute the questionnaire in their cities. Without your support this work cannot be conducted on a national scale. We are grateful for the reviewers detailed suggestions that have resulted in great improvements in the quality of this paper.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jclepro.2018.03.253>.

References

- Aksen, D., Aras, N., Karaarslan, A.G., 2009. Design and analysis of government subsidized collection systems for incentive-dependent returns. *Int. J. Prod. Econ.* 119, 308–327.
- Babatunde, O.A., Eguma, C.A., Oyeledun, B.T., Igwilo, O.C., Awosanya, O.G., Adegbenro, O., 2014. Mobile phone usage and battery disposal in Lagos, Nigeria. *Int. J. Appl. Psychol.* 4, 147–154.
- Baxter, J., Gram-Hanssen, I., 2016. Environmental message framing: enhancing consumer recycling of mobile phones. *Resources. Conserv. Recycl.* 109, 96–101.
- Baxter, J., Lyng, K., Askham, C., Hanssen, O.J., 2016. High-quality collection and disposal of WEEE: environmental impacts and resultant issues. *Waste Manag.* 57, 17–26.
- Global Attitude Survey, 2015. <http://www.pewglobal.org/2016/02/22/smartphone-ownership-and-internet-usage-continues-to-climb-in-emerging-economies/>.
- Guo, X., Liu, J., Qin, H., Liu, Y., Tian, Q., Li, D., 2015. Recovery of metal values from waste printed circuit boards using an alkali fusion–leaching–separation process. *Hydrometallurgy* 156, 199–205.
- Guo, X., Yan, K., 2017. Estimation of obsolete cellular phones generation: a case study of China. *Sci. Total Environ.* 575, 321–329.
- Hanafi, J., Christiani, A., Kristina, H.J., Utama, K.P., 2013. Collecting end-of-life mobile phones in Jakarta: a pilot. In: Nee, A., Song, B., Ong, S.K. (Eds.), *Re-engineering Manufacturing for Sustainability*. Springer, Singapore.
- International Telecommunication Union Yearly Report 2015, <http://news.sohu.com/20151201/n429091410.shtml>.
- Jang, Y., Kim, M., 2010. Management of used & end-of-life mobile phones in Korea: a review. *Resour. Conserv. Recycl.* 55, 11–19.
- Koga, G.A., Maccari, E.A., Kniess, C.T., Ruiz, M.S., 2013. Consumer's perception regarding recycling of mobile phones: a prospective assessment in the State of São Paulo, Brazil. In: 2013 Proceedings of PICMET '13: Technology Management for Emerging Technologies.
- Li, B., Yang, J., Lu, B., Song, X., 2015. Estimation of retired mobile phones generation in China: a comparative study on methodology. *Waste Manag.* 35, 247–254.
- Li, B., Yang, J., Song, X., Lu, B., 2012. Survey on disposal behavior and awareness of mobile phones in Chinese university students. *Procedia Environ. Sci.* 16, 469–476.
- MIIT, 2016. <http://www.miit.gov.cn/n1146312/n1146904/n1648373/c5450498/content.html>.
- Monteiro, M.R., Moreira, D.G.G., Chinelatto, M.A., Nascente, P.A.P., Alcântara, N.G., 2007. Characterization and recycling of polymeric components present in cell phones. *J. Polym. Environ.* 15, 195–199.
- Nielson Mobile Consumer Report, 2013. <http://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2013%20Reports/Mobile-Consumer-Report-2013.pdf>. (Accessed 2017).
- Nnorom, I.C., Ohakwe, J., Osibanjo, O., 2009. Survey of willingness of residents to participate in electronic waste recycling in Nigeria – a case study of mobile phone recycling. *J. Clean. Prod.* 17, 1629–1637.
- Ongondo, F.O., Williams, I.D., 2011. Greening academia: use and disposal of mobile phones among university students. *Waste Manag.* 31, 1617–1634.
- Paiano, A., Lagioia, G., Cataldo, A., 2013. A critical analysis of the sustainability of mobile phone use. *Resources. Conserv. Recycl.* 73, 162–171.
- PEW Research Center Report, Spring 2015, <http://mo.techweb.com.cn/2016-05-11/2330764.shtml>. (Accessed 2017).
- Polak, M., Drapalova, L., 2012. In: Lang, K.D., Nissen, N.F., Middendorf, A., Chancerel, P. (Eds.), *Analysis of Lifespan of Mobile Phones: Estimation of EoL Mobile Phones Generation*.
- Rahmani, M., Nabizadeh, R., Yaghmaeian, K., Mahvi, A.H., Yunesian, M., 2014. Estimation of waste from computers and mobile phones in Iran. *Resour. Conserv. Recycl.* 87, 21–29.
- Sarath, P., Bonda, S., Mohanty, S., Nayak, S.K., 2015. Mobile phone waste management and recycling: views and trends. *Waste Manag.* 46, 536–545.
- Silveira, A.V.M., Fuchs, M.S., Pinheiro, D.K., Tanabe, E.H., Bertuol, D.A., 2015. Recovery of indium from LCD screens of discarded cell phones. *Waste Manag.* 45, 334–342.
- Wang, Y., Ma, J., Ma, B., 2013. Status of mobile phone recycling in China and research of recycle models. *China Econ.* 51–53.
- Wang, Z., Zhang, B., Yin, J., Zhang, X., 2011. Willingness and behavior towards e-waste recycling for residents in Beijing city, China. *J. Clean. Prod.* 19, 977–984.
- WEEE Catalog (2014 edition), http://www.ndrc.gov.cn/zcfb/zcfbgg/201502/t20150213_664456.html.
- Wei, L., Liu, Y., 2012. Present Status of e-waste Disposal and Recycling in China. *Procedia Environ. Sci.* 16, 506–514.
- Welfens, M., Nordmann, J., Seibt, A., Schmitt, M., 2013. Acceptance of mobile phone return programs for increased resource efficiency by young people—experiences from a German research project. *Resources* 2, 385–405.
- Welfens, M.J., Nordmann, J., Seibt, A., 2016. Drivers and barriers to return and recycling of mobile phones. Case studies of communication and collection campaigns. *J. Clean. Prod.* 132, 108–121.

- Yang, J., Lu, B., Xu, C., 2008. WEEE flow and mitigating measures in China. *Waste Manag.* 28, 1589–1597.
- Yin, J., Gao, Y., Xu, H., 2014. Survey and analysis of consumers' behaviour of waste mobile phone recycling in China. *J. Clean. Prod.* 65, 517–525.
- Ylä-Mella, J., Keiski, R.L., Pongrácz, E., 2015. Electronic waste recovery in Finland: consumers' perceptions towards recycling and re-use of mobile phones. *Waste Manag.* 45, 374–384.
- Yu, J., Williams, E., Ju, M., 2010. Analysis of material and energy consumption of mobile phones in China. *Energy Pol.* 38, 4135–4141.
- Zhou, L., Xu, Z., 2012. Response to waste electrical and electronic equipments in China: legislation, recycling system, and advanced integrated process. *Environ. Sci. Technol.* 46, 4713–4724.