



# Consumer behavior with respect to the consumption and recycling of smartphones and tablets: An exploratory study in Portugal



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## ABSTRACT

A better understanding of how smartphones and tablets are managed at the end of their life cycle is needed to achieve higher recycling and reuse rates. The goals of this study were to obtain the current consumption (acquisition and use) and recycling behavior of consumers with respect to smartphones and tablets from an exploratory online survey implemented in Portugal, and to identify the socio-demographic factors that influence the consumption and recycling behaviors related to these types of device. The survey reveals that smartphones and tablets had a mean life of use of three years. Smartphones were bought mainly in stores, and tablets were bought in stores or were received as gifts from friends or family. Concerning device use, respondents reported an average of 3.34 smartphones per person, including those in use, used, or broken, with the majority in use. An average of 1.06 tablets were in use, used, or broken per person, also with the majority in use. A Chi-square analysis showed a statistically significant relationship between all the tested sociodemographic variables, and gender, family size, and occupation were the variables most closely related to consumption and recycling behaviors. Of note, apart from their opinions on the importance of recycling, consumers' attitudes were dedicated mostly to reuse actions, such as keeping the devices in the home or giving them to a relative or friend to use. To increase collection and recycling rates, environmental awareness campaigns are needed to increase consumers' knowledge of existing collection and recycling programs.

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## 1. Introduction

Waste electrical and electronic equipment (WEEE) is one of the fastest growing waste streams in Europe (European Union, 2016). In 2013, around 8.1 million metric tonnes of electrical and electronic equipment (EEE) (Eurostat, 2016a) were produced in Europe, making EEE a fast-growing source of WEEE. WEEE is characterized by its partly hazardous content, including chlorinated biphenyls, brominated flame retardants, and other hazardous materials, as well as its valuable contents, including copper, precious metals, and “critical” metals, as defined in European Commission (2010). To prevent an increase in the amount of WEEE in the waste stream, the European Union (EU) promotes the reuse, recycling, and other forms of recovery of EEEE through Directive 2002/96/EC

(subsequently replaced by Directive, 2012/19/EU) to ensure adequate management of end-of-life EEE. In the latest directive, the minimum collection rate for 2016 was set at 45% of the weight-based total, rising to 65% in 2019, with the latter figure being the predicted percentage of the average weight of EEE put into the market collected in the preceding three years. In 2019, EU Member States will also be able to calculate the collection rate based on the amount of WEEE generated in that year, with a target of 85% (European Parliament and Council, 2012).

Until now, the collection rate of WEEE in European countries has been lower than the targets defined in the WEEE directive. According to Eurostat (2016a), of the 28 Member States (EU-28), only 9 reached the 2016 target; for the other members, collection rates varied from 11% to 42%. In Portugal, the collection rate was 37% in 2013 (the mean rate for the three preceding years, 2010–2012) (Eurostat, 2016b), but more effort is needed to achieve both the target set for 2016 and future targets. Low collection rates were observed by Huisman et al. (2007), who noted that appliances lighter than 1 kg and small items of WEEE, commonly information technology (IT) and telecommunications equipment, have a low

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return (collection) rate, a problem also noted by Polák and Drápalová (2012) for the Czech Republic, where only 3%–6% of used mobile phones were collected for recovery and recycling in 2010. In 2013, large household appliances accounted for 1.6 million tonnes or 51% of the total WEEE collection in EU-28, followed by IT and communication equipment with 575,260 tonnes (18%), consumer equipment with 553,421 tonnes (17%), small household appliances with 254,406 tonnes (8%), and other types of WEEE with 200,603 tonnes (6%) (Eurostat, 2016a).

Various reasons have been given for the low collection rates observed in formal schemes. Chi et al. (2014) found in China that informal collection is the primary disposal option for household WEEE owing to advantages such as collection scope, the convenience of service, flexibility, and accessibility. Cao et al. (2016) also confirmed that users of EEE in China are unable to distinguish between formal and informal collection channels. Also, informal collection schemes are responsible for exporting large amounts of WEEE, mainly to countries with low environmental standards, a recent common occurrence in Germany, for example (Salhofer et al., 2015). Although these exports were considered as used EEE items, in reality they were WEEE items, a problem also found in Ghana, where 30% of used EEE is in fact WEEE (Schluep et al., 2011; Tanskanen, 2013). Another reason for low collection rates is related to WEEE flow, which is characterized by the delay between the end of life of EEE (i.e., WEEE) and the delivery of WEEE items to be recycled. Several studies indicate that a large fraction of small EEE items do not currently enter WEEE recovery systems, yet such items are not in use (Gutiérrez et al., 2010; Ongondo and Williams, 2011; Pérez-Belis et al., 2013; Polák and Drápalová, 2012). For example, in China, 70% of used EEE items are stored at home or in work offices, with storage times varying from months to years (Yang et al., 2008); in Finland, a survey conducted by Ylä-Mella et al. (2015) found that 85% of users stored their unused mobile phones at home. The collection infrastructure has also been noted as being problematic for achieving higher collection rates. Friege et al. (2015) and Tojo and Fischer (2011) argued that systems with reduced municipal involvement have low levels of success because these systems require close contact with citizens to make the collection scheme work; systems that provide more information and which have easier access perform better (Beigl et al., 2012; Friege et al., 2015). Welfens et al. (2015) found that economic incentives, education, and communication play relevant roles in IT and communication sector recycling and that without these aspects, it is difficult to attain high collection rates.

The common factor among the various aforementioned issues regarding collection efficacy is the consumer/user/owner of used EEE and WEEE items. Reaching WEEE collection targets requires an in-depth knowledge of how the consumer adopts pro-environmental behaviors, such as the acquisition and use (here referred to as “consumption”) of EEE and the recycling of WEEE, especially for IT and communication WEEE items. Several studies have investigated the factors that may influence the behavior of consumers concerning IT and communication WEEE, particularly with respect to mobile phones. In Finland, Ylä-Mella et al. (2015) noted that most consumers have two or more mobile phones at home, but although their awareness of the waste recovery system is high, it has not translated to recycling behavior. Those authors’ investigation demonstrated that the existing collection system is inadequate to promote the return of used mobile phones. Yin et al. (2014) studied mobile phone recycling in China and found that the actual service time is shorter than 3 years, with most consumers being willing to pay just 0%–5% of the associated recycling costs. Islam et al. (2016) studied WEEE in Bangladesh and found that the actual life cycle of mobile phones, personal computers, and television sets varies from 2 to 6 years, with only 5%–10% of

respondents being willing to pay for a new WEEE management system. In Australia, the number of mobile phones in use has been estimated at two phones per capita, with an average time of active use being in the range of 2.0–2.6 years (Golev et al., 2016).

The main goal of the present study was to examine, from an exploratory perspective, consumption behavior and recycling behavior (with recycling being defined as the separation of waste to be recycled) in Portugal concerning two increasing streams of EEE, namely, smartphones and tablets. Exploratory studies are needed when little is known about a particular product (Mariampolski, 2001), which is the case with smartphones and tablets with respect to WEEE and recycling. The choice of these two particular IT and communication WEEE items is justified by their growing use worldwide, the hazardous nature of their recycling process, and the need to increase interest in the critical and valuable raw materials that they contain. In 2015, more than 7 billion mobile cellular subscriptions existed worldwide (International Telecommunication Union, 2016), and around 248 million tablets were shipped worldwide. These numbers are expected to rise through to 2018 partly because tablets are replacing desktop PCs. Around 1.4 billion smartphones were sold to end-users worldwide in 2015 alone (Statista, 2016). Despite the global diffusion and existing number of smartphones and tablets, the number of studies of devices that use mobile Internet services with respect to waste and recycling is low, justifying the need for the present study.

## 2. An overview of used smartphone and tablet management in Portugal

End-of-life smartphones and tablets are managed according to WEEE Portuguese national regulations, derived from the EU Directive of Category 3 for IT and communication equipment. The management of these devices is the responsibility of producers and importers, who can manage their EEE either individually or through a producer responsibility organization (PRO) by transferring their obligation to the PRO by paying a fee, in accordance with the principle of the extended producer responsibility (EPR). The PROs must establish a separate collection system for WEEE items, ensure their appropriate treatment, and conduct awareness campaigns to promote the separation of WEEE from commingled urban waste.

Two PROs exist in Portugal, namely, Amb3E and ERP Portugal, and they are competitors. Both are obligated to comply with collection, recovery, and recycling targets established in Directive 2012/19/EC (European Parliament and Council, 2012) and transposed into national law by “Decreto-Lei n.º 67/2014, 7 de maio” (Conselho de Ministros, 2014). Both entities are charged with managing WEEE collection and treatment systems. In those systems, consumers may deliver WEEE at drop-off containers. Drop-off containers, referred to as “Depositrão” and “Ponto Electrão”, are located in shopping centers, EEE stores, fire stations, private waste operators’ premises, and a limited number of street locations. Consumers can also deliver WEEE to distributors’ premises. According to Directive 2012/19/EC, “distributors are a natural or legal person in the supply chain who makes an EEE available on the market” (European Parliament and Council, 2012). WEEE items can be delivered to distributors at a ratio of 1:1 of the old device to a new device, without charge, or, if the store has a sales area of at least 400 m<sup>2</sup>, the store is obligated to receive very small WEEE items (no external dimension greater than 25 cm) without any further obligation being placed on the end user to buy a similar EEE item. Recycling centers also receive WEEE from private consumers for free. In 2015, Amb3E represented 1378 EEE producers and collected 36,845 tonnes of WEEE, whereas ERP represented 472 EEE producers and collected 16,254 tonnes of WEEE (Amb3E, 2016; ERP

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