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Consumer behavior towards consumption, disposal, and awareness of household e-waste: A study in Portugal.

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Abstract

To increase the Portuguese e-waste household collection rate, more excellent knowledge of how consumers manage their end-of-life electronic equipment is necessary. This research paper aims to understand Portuguese citizens' current consumption trends, how they dispose of their e-electronic appliances, and how much they know about e-waste and its implication on the environment. This analysis was carried out in two steps: first, a questionnaire was administered in Portugal, and the findings were analyzed. Secondly, a statistical analysis was conducted to find an association between consumer behavior and sociodemographic characteristics. Age, education, employment, family size, employment, and income are significantly associated with consumption, disposal, and awareness. The findings suggest that large appliances hold the highest percentage of household equipment, followed by small appliances and It and Telecommunication equipment, and the average substitution time is four years. A slight but non-indifferent tendency shows consumers are willing to buy second-handed equipment. Moreover, regarding disposal, there is still the tendency to abandon large equipment on the street and store small items for sentimental or future-usage reasons. Incentives are appreciated, such as cash-back and discounts on new-green items. Other than the practices already in existence in Portugal, the government, policymakers, municipalities, and PRO must raise awareness in different ways among the sociodemographic classes studied to correct bad habits and increase recycling properly.

Keywords: Consumer Behavior, Household E-waste, Consumption, Disposal and Awareness.

Introduction

The problem of household e-waste presents a global challenge. The rapid technological revolution and increasing consumer demand for high-tech products have triggered unprecedented levels of electrical and electronic equipment consumption. At the same time, electric and electronic appliances are now part of the average consumer's daily life. The lifespan of products has been shortened by the advancements of more efficient, quick, and trustworthy processing technologies, which have encouraged consumers to buy more up-to-date appliances and dispose of obsolete ones. The implication of the higher usage of electronic and electric equipment shows how much humans, who represent only 2,25% of the world's carbon biomass, cause instability in the global living biomass (Venditti, 2021). Indeed, to produce e-products people consume, there is the need to scrap the earth's mass and extract metal ores, causing society's intake of materials that are non-circular and will therefore cause waste and CO2 emissions. Nowadays, only 7 out of 39 gigatons the world uses are processed and reintroduced in a circular system (Venditti, 2021).

The Circular Economy (CE) is a regenerative system where waste, emissions, and energy losses are minimized within its resources, thus slowing down pollution processes (Geissdoerfer et al., 2020). This concept can only be put into practice by implementing the 4Rs principles: reduction, reuse, recovery, and recycling (Bressanelli et al., 2016). Understanding circularity's paradigm is extremely important because, as the world is interconnected, the impact of material used will affect the three planetary crises: climate, nature, and pollution. As such, the more electronic equipment consumed, the worse the effect on human well-being.

Among the several reasons e-waste management is essential, the materials in EEE contain hazardous, valuable, and scarce resources. From heavy metals such as lead, or chemicals such as chlorofluorocarbon (CFCs), to valuable materials which can be recycled as palladium, silver, or platinum. E-waste, thus, offers a significant number of secondary resources for remanufacturing, refurbishing, and recycling. Consequently, since electronic waste, when it has reached the end of its useful life, offers a severe environmental concern on human health due to the presence of highly toxic substances, but also can be a valuable source of remanufactured material since it can be recovered up to 90/100 percent (Parajuly et al., 2017). Consequently, raising awareness among all the stakeholders involved in the e-waste management process is crucial to have a positive outlook in the future.

According to the Unitar global e-waste Monitor (2020), the average per capita of e-waste generated in Europe is 16.2 kg, and in the past years, it has been growing at a pace of 3 to 5 percent per year. According to the European Circular Economy Action Plan (2020), less than 40% of electronic waste is recycled in the EU.
In fact, the EU has mandated a minimum collection rate target of 65% (2020) in its most recent legislation to ensure effective treatment of e-waste. The rate of WEEE collection in European nations has, up to this point, lagged below the goals outlined by European Directives. As seen in Figure 1.1, e-waste management can be

described as a complex environment where different stakeholders interact. One of the essential waste management points is consumers, who determine its destination (Figure 1.1).

1.1 Purpose and Relevance of this Study

In Portugal, WEEE's collection rate is below 40% out of the 65% target. Per capita collection accounts only for 5.8 kilos (Eurostat 2023), showing a relevant fallacy of consumers' understanding of e-waste management. However, the lack of empirical evidence on the contribution of the possible reasons for which Portugal's per capital collection is this low is restricting the formulation of strategies that can help to increase WEEE collection targets. A thorough understanding of how consumers adopt pro-environmental behaviors, such as consumption and awareness of EEE, and disposal of WEEE for private household EEE equipment is, therefore, needed and represents the goal of this study.

1.2 Structure

This paper is structured as follows: Chapter 2 lists the existing literature on the topic, displays research findings from other scholars, and analyzes the current situation in Portugal. Chapter 3 describes the research methodology, survey design, and data collection, highlighting the characteristics of the empirical analysis. Chapter 4 deals with descriptive and statistical findings. Chapter 5 discusses the findings with a focus on managerial implications. Finally, Chapter 6 concludes.

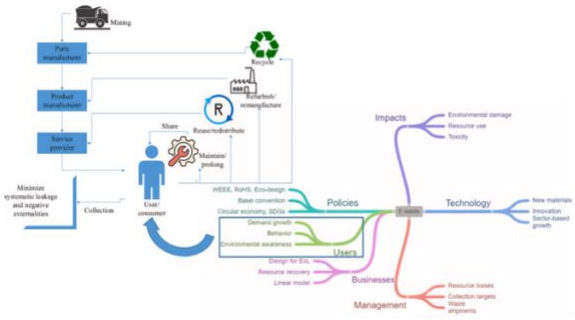


Figure 1: Conceptual Framework of e-waste process
Source: Islam M. et al., 2021

2. Literature Review

The literature review is going to be structured into four sections. The first section aims to give an overview of the European and Portuguese legislation regarding e-waste. The other three section focuses on consumer behaviors towards consumption, disposal, and awareness of household e-waste.

2.1 Overview of the European and Portuguese legislation regarding e-waste

2.1.1 European legislation

Electrical and Electronic equipment is defined, according to Directive 2021/19/EU of the European Parliament and of the Council on the 4th of July 2021, as "*equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for the direct current".* Furthermore, according to the same directive, article 3E, the waste which is derived from this equipment (WEEE) shall include "*all the components, sub-assemblies and consumables which are part of the product at the time discarding*."

The directive classifies the items based on six categories: temperature exchange equipment, screens, lamps, large equipment, small equipment, IT, and telecommunication equipment (Appendix I). Since Directive 2002/95/EC of the European Parliament, the European Commission has been amending the part which tackles the technical progress towards the hazardous substances contained in the EEE. Indeed, WEEE incorporates a wide range of pollutants, as in many cases, it includes many heavy materials, such as lead, cadmium, and mercury. However, the constituents used in larger quantities are plastics (of different polymers), metals (e.g., iron, steel, aluminum, copper), glass, and rubbers.

As such, the recycling of WEEE presents the central problem of the presence of a wide variety of materials in each product and the high degree of hazardousness of the substances that constitute them, making their recovery more difficult (Grigorescu et al., 2019). For instance, fluorescent lamps that use mercury with monitors of cathode ray tubes that have in their constitution glass composed of heavy mantels and other polluting substances, and appliances such as refrigerators that used to insert CFCs in their refrigeration circuits. Until recently, the most common destinations for WEEE were dumps, landfills, incineration, or sometimes recovery without any pre-treatment.

For this reason, the directive clearly states that "*Member States shall adopt appropriate measures to minimize the disposal of WEEE in the form of unsorted municipal waste, to ensure the correct treatment of all collected WEEE and to achieve a high level of separate collection of WEEE, notably, and as a matter of priority, for temperature exchange equipment containing ozone-depleting substances and fluorinated greenhouse*

gases." Regarding e-waste from private households, *each member state* is responsible for ensuring that the systems are in place to let final holders and distributors return e-waste garbage for free. Member states are responsible for ensuring the accessibility and availability of the required collection facilities, considering population density (Directive 2021/19/EU).

One crucial principle which shall apply in the directive is the one of Producer Responsibility, which establishes *a minimum collection rate of 65% on the average of EEE placed in the market* and a minimum rate of separate collection of at least *4 kilograms on average per inhabitant per year of WEEE from private households.* Indeed, producers are permitted to establish and run individual and collective take-back systems for WEEE from private households if they align with the directive's goals. As much as they are responsible for collecting systems, producers must guarantee the financing of the operations, such as collection, treatment, or recovery, of their equipment emitted in the market. Instead, distributors, *when supplying a new product*, must make sure that the waste can be returned to them free of charge or on a one-to-one basis when supplying a new product, provided that the equipment is of an equivalent type and has performed the same functions as the given equipment (Directive 2021/19/EU).

Furthermore, distributors must allow for collecting very small WEEE at retail stores with electric and electronic equipment (EEE) sales areas of at least 400 m2 or in their immediate vicinity, free of charge to end-users and without requiring them to purchase EEE of an equal type. From regard to users' perspective, Member states must provide information regarding the prohibition on disposing of WEEE in unsorted municipal waste and the requirement to collect such waste separately; not only, but they must also inform the return and collection system available to them, encourage the coordination of information of the available collection points, also their part in helping recover WEEE through reuse, recycling, and other methods, the possible negative consequences on the environment and human health due to the presence of hazardous materials in EEE (Directive 2021/19/EU).

Member States shall ensure that producers appropriately mark, under the European standard EN 50419, EEE placed on the market with the symbol shown in Appendix II. Finally, to offer an overview of the European trend during these past eight years, from the graph below, it is possible to analyze the EEE inserted in the market in WEEE collected, treated, recovered, recycled, and prepared for reuse. With a record of 12.4 million tonnes in 2020, EEE sold in the EU increased from 7.6 million tonnes in 2012. The year with the lowest level over this time frame was 2013, with 7.3 million tonnes. The total volume of EEE released onto the market from 2012 to 2020 increased by almost 65%. While the overall amount of treated WEEE climbed from 3.1 to 4.6 million tonnes, the total amount collected increased from 3.0 to 4.7 million tonnes by almost 60%. Between 2012 and 2020, recovered WEEE increased from 2.6 to 4.3 million tonnes (+65.1%), while WEEE that had

been recycled and was ready for reuse increased from 2.4 to 3.9 million tonnes (+61.7%) (Eurostat Waste statistics-electrical and electronic equipment).

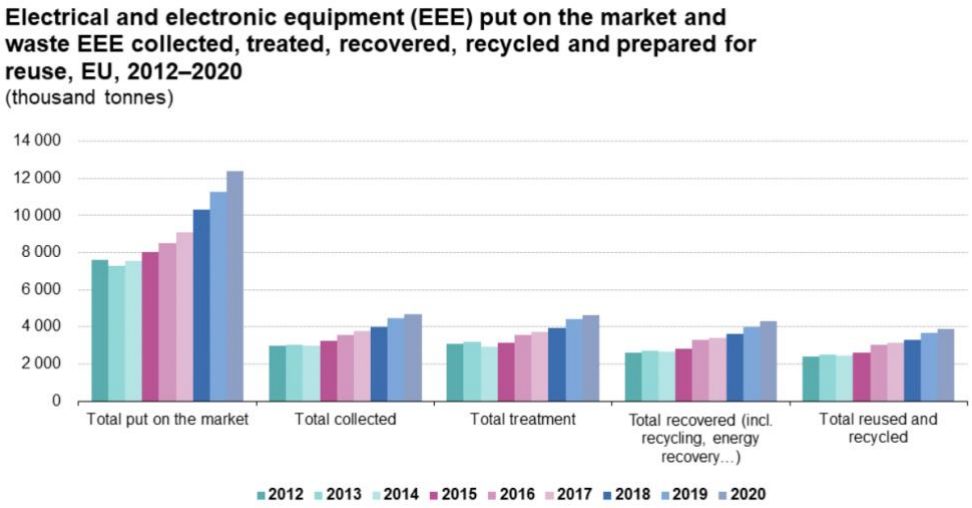


Figure 2: EEE put on the market (EU)
Source: Eurostat (online datat code: env_waseleeos and env_waselee)

2.1.2 Portuguese Legislation

The Portuguese Legislation, more specifically, *Decreto-Lei n. º 102-D/2020, de ten de dezembro*, has been enacted to comply with the European Union Directives. The priority of the Portuguese law decree states the principle of health prevention, which means ensuring that waste management is carried out using methods that are not likely to generate adverse effects on the environment and human health. This law decree, as one No. 152D/2017 of 11 December, unifies the management of specific waste streams subject to extended producer responsibility.

The principle of *responsaibilidade alargada do productor* states that producers and importers of electronic and electric equipment are required to finance the collection and treatment of waste generated by their products (Figure 2). The producer's responsibility may be assumed individually or transferred to an integrated system, which can be private or public. The implementation of these measures was materialized by the implementation of the following WEEE management collective systems' entities or Producer Responsibility Organizations (PROs) since 2006: the first one is *Electrão*, which before was named *AMB3E*, the second one is ERP Portugal, and the third one, which was implemented more recently in 2018, is *WEEECYCLE*.

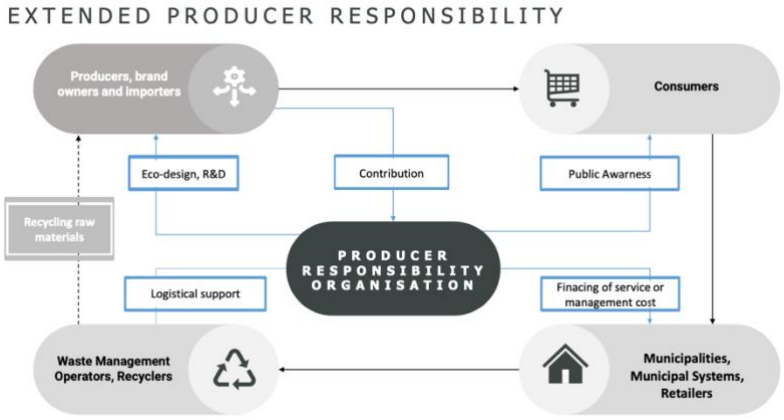


Figure 3: Producer Responsibility Organization
Source: Electrão

Regarding national targets for collection and recovery, the percentage has been increased since 2016; it was 45% of the average weight of EE placed on the market, considering the total weight from private and non-private consumers, instead from 2019 it is 65%. According to article 7 of the "Decreto-Lei n. º 102-D/2020", "*com vista à transição para uma economia circular… no que se refere às opções de prevenção e gestão de resíduos, a seguinte ordem de prioridades; prevenção; preparação para a reutilização; reciclagem; outros tipos de valorização; eliminação",* to ease the circularity of e-waste, the most important areas which need to be improved are prevention, preparation for reuse, recycling, and disposal.

Consumers must adopt practices that facilitate the reuse of products to increase their useful life, and waste producers must adopt preventive behavior regarding the quantity and danger of waste, such as the separation of waste sources, to promote its separation for reuse, recycling, and other forms of recovery. Several plans were created jointly with municipalities, inter-municipalities, and multi-municipalities to deliver an efficient plan for administering waste. The entities responsible in Portugal for overseeing the implementation of the European directive are the *Agência Portuguesa do Ambiente* (APA) and Entitade Reguladora dos Servicios (ERSAR).

The role of citizens is apparent in this regard. Citizens are responsible for separating and depositing e-waste produced in their homes at the collection points or centers provided by the entities providing the waste collection and treatment service or at places authorized for this purpose. Citizens can suffer specific administrative offenses, stipulated by municipal service regulations, for the failure to comply with the duty to separate and deposit household e-waste at the places and the days set aside for this purpose (Law no.73/2013). Municipal and multi-municipal systems must hold awareness campaigns for citizens to encourage a reduction in waste production and transmit information regarding selective collection. Furthermore, these entities must communicate the results and benefits obtained by citizens through participation in effective e-waste management once a year. In this regard, APA has published the management results achieved at the national

level for each specific waste stream. As it possible to see, there is a big gap between the EEE placed on the market, and the WEEE collected from private households.

Country: PT Reference year: 2019		Portugal																	
		EEE placed on the market (POM) (Tonnes)	Standard footnotes	Explanatory footnote	WEEE Generated (Tonnes)	Standard footnotes	Explanatory footnote	WEEE collected from private households (Tonnes)	Standard footnotes	Explanatory footnote	WEEE collected from users other than private households (Tonnes)	Standard footnotes	Explanatory footnote	Total WEEE collected (Tonnes)	Standard footnotes	Explanatory footnote	WEEE treated in the Member State (Tonnes)	Standard footnotes	Explanatory footnote
waste code	waste description	MKT			GEN			COL_HH			COL_OTH			COL			TRT_NAT		
EE_TEE	1. Temperature exchange equipment	51315,88						9452,87			3317,07			12769,94			12769,94		
EE_SME	2. Screens, monitors, and equipment containing screens having a surface greater than 100 cm2	9965,03						3620,04			1691,48			5311,52			5273,53		
EE_LMP	3. Lamps	1366,53						423,29			766,26			1189,55			1208,83		
EE_LE	4. Large equipment (*) (any external dimension more than 50 cm)	95918,31						8134,27			5243,22			13377,49			13377,49		
EE_LEXPVP	4a. Large equipment excluding photovoltaic panels (*)	71602,93						8134,27			5217,92			13352,19			13352,19		
EE_LE_PVP	4b. Photovoltaic panels (*)	24315,38						0			25,3			25,3			25,3		
EE_SE	5. Small equipment (no external dimension more than 50 cm)	36987,6						8198,08			5510,42			13708,5			13227,51		
EE_SITTE	6. Small IT and telecommunications equipment (no external dimension more than 50 cm)	8367,46						2252,46			3868,78			6121,24			6121,24		
EE6	Total waste arising from EEE (6 categories)	203920,81						32081,01			20397,23			52478,24			51978,54		

Country: PT Reference year: 2019		Portugal																	
		Recovery (Tonnes)	Standard footnotes	Explanatory footnote	Recovery rate (%)	Standard footnotes	Explanatory footnote	Preparing for re-use and recycling (Tonnes)	Standard footnotes	Explanatory footnote	Preparing for re-use and recycling rate (%)	Standard footnotes	Explanatory footnote	Preparing for re-use (Tonnes)	Standard footnotes	Explanatory footnote	Recycling (Tonnes)	Standard footnotes	Explanatory footnote
waste code	waste description	RCV			RCV			RCY_PRP_REU			RCY_PRP_REU			PRP_REU			RCY		
EE_TEE	1. Temperature exchange equipment	11359,02			88,95124018			10283,86			80,5317801			139,62			10144,24		
EE_SME	2. Screens, monitors, and equipment containing screens having a surface greater than 100 cm2	2281,96			42,96246649			2117,78			39,87144923			27,06			2090,72		
EE_LMP	3. Lamps	1080,97			90,87217855			1028,27			86,44193182			3,73			1024,54		
EE_LE	4. Large equipment (*) (any external dimension more than 50 cm)	12328,35			92,15742266			11434,19			85,4733586			65,13			11369,06		
EE_LEXPVP	4a. Large equipment excluding photovoltaic panels (*)	12328,35			92,33204441			11434,19			85,63531526			65,13			11369,06		
EE_LE_PVP	4b. Photovoltaic panels (*)	0			0			0			0			0			0		
EE_SE	5. Small equipment (no external dimension more than 50 cm)	12759,33			93,07604771			11707,88			85,40598898			105,37			11602,51		
EE_SITTE	6. Small IT and telecommunications equipment (no external dimension more than 50 cm)	5094,2			83,22170018			4603,93			75,21237527			321,57			4282,36		

Figure 4: Resíduos de Equipamento Elétrico e Eletrónico (REEE)
Source: APA

2.2 Consumers' Consumption, Disposal and Awareness

2.2.1 Consumer consumption and reuse of E-waste, with focus on Portugal

The average per capita consumption of EEE is increasing, as well as the waste generated from this consumption. As shown in Figure 5, through the EU, the EEE put on the market per inhabitant is higher in all countries than the WEEE collected per inhabitant, showing not only inefficiency at the European level but also at the national level. Indeed, considering Portugal, the EEE put on the market from 2017 to 2019 is equal to 17,6 kg per inhabitant, and the WEEE collected from inhabitants is just 5,8 kg. Considering this analysis, Portugal has one of the lowest collection rates in Europe, raising the paradox between the rise of the per capita consumption of EEE and its collection system.

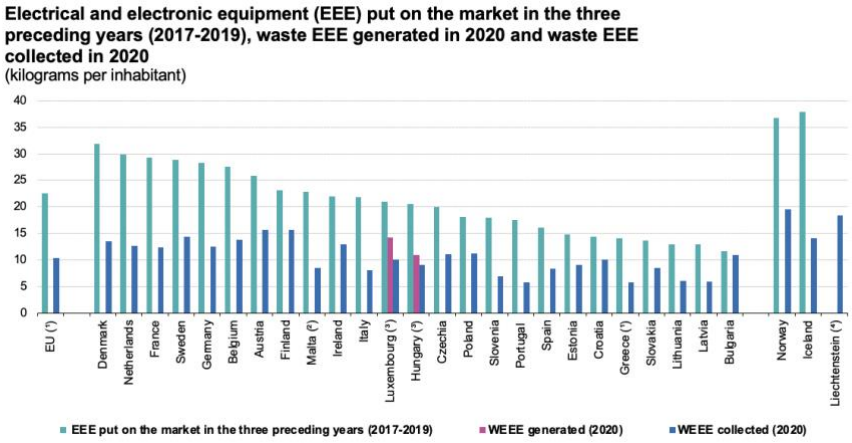


Figure 5: EEE put on the market in the three preceding years (2017-2019)
Source: Eurostat (inline data code: env_waseleeos)

According to the United Nations Global Monitoring of E-waste (2020), electrical and electronic products are crucial components that contribute to world development. Nonetheless, ownership rates differ according to sociodemographic characteristics, such as household income, how many people live in each household, and age (Wieser H. et al., 2018).

Figure 6: Global average number of selected appliances owned per capita, by country's income level
Source: United Nations

Going more in-depth with the categories of EEE in Portugal, cooling and freezing equipment accounted for the majority of the WEEE produced in Portugal (30.4% of the total), followed by small (21.3%) and large (19.3%) household appliances. Each of the remaining WEEE categories contributed less than 10% overall (Eurostat, WEEE Data Tables). More in-depth, regarding major appliances in Portugal, the most revenues are generated from refrigerators, then washing machines, cookers and ovens, dishwashers, and freezers (STATISTIA 2022 N.1).

One exciting aspect is the consumer tendency to buy new electrical equipment. During the last years, consumers have tended to buy more temperature exchange equipment, which had an average yearly increase of 7%, followed by large equipment (+5%), lamps, and small equipment (+4%) (United Nations e-waste monitoring). The change in climatic conditions can cause the former increase in the acquisition by consumers (Cai et al., 2020), affecting mainly the acquisition of larger appliances such as air conditioning. Other reasons found in past research show a positive relationship between the income growth of customers. However, also the fact that technological change is more affordable, and the pace of its change is faster (Shaikh et al., 2020). The latter is a significant problem that causes consumers to buy electronic and electric equipment. The ownership levels vary accordingly to different categories of appliances; indeed, IT equipment, such as mobile phones, have the highest per-capita consumption, sometimes they are changed even two years after the acquisition, while larger appliances such as Washing Machines, Dish Washers are changed after four years (Araujo et al., 2017).

As regards the technical condition of the EEE replaced, studies in this area have shown that the reason “to be broken” is not the main one as thinkable (Islam M. et al., 2021). Instead, technological obsolesce, or perceived technological obsolescence, especially in the IT and Telecommunication category, is the main reason for the change. This tendency can be found in several countries in which research has been conducted, such as Australia, Spain, the UK, Brazil, and Canada, but also Portugal, where it was observed that the reason “broken” accounted for 30% of the survey’s result. In contrast, the others were “out-to-date functionalities, or “dead battery” (Martinho et al., 2017).

Consumers generally prefer buying new electronic appliances without feeling the need to repair the item. (Bovea et al., 2017; Chi et al., 2014). Although in some European nations, the use of reuse and repair and second-hand sales strategies are well-established and accepted activities that do not directly compete with the first-sale market because the buyer and seller profiles for second-hand transactions are different from those for new purchases, the culture is still underdeveloped (Bovea et al., 2017). Moreover, the technical condition of the items can be determinant since if items can be appropriately reused, there will be less waste (Chi et al., 2014).

2.2.2 Consumer household e-waste disposal, with focus on Portugal

Many options are available to consumers who wish to dispose of their unwanted EEE. A formal disposal route may be organized and managed by government agencies, or regional scrap metal recyclers, paddlers, and rubbish collectors may provide an unofficial collection service. A second method is often used in developing nations where recycling is achieved using primitive techniques such as acid leaching. Identifying "disposal patterns" is a key challenge to improving the e-waste collection system (Islam M. et al., 2020). It is critical to understand how consumers dispose of their domestique appliances since it shows where governments or policymakers can improve to deviate consumers' behavior towards a correct disposal system positively.

However, the biggest problem is that the disposal of waste used by consumers is not going to official collection and recycling systems. As it is possible to see in this graph, which offers an overview of all the European countries, the e-waste generated goes to different streams other than the "official reported" and the "export for reuse," as the mixed "waste bin," "non-compliant recycling" and a "gap" space. More in detail, it is possible to analyze the case of Portugal, wherein just over 22% of the e-waste is reported, 10% goes to the mixed waste bin, 20% is not compliant with recycling, and other is not defined as it is shown in the gap column (Collectors EU, 2020).

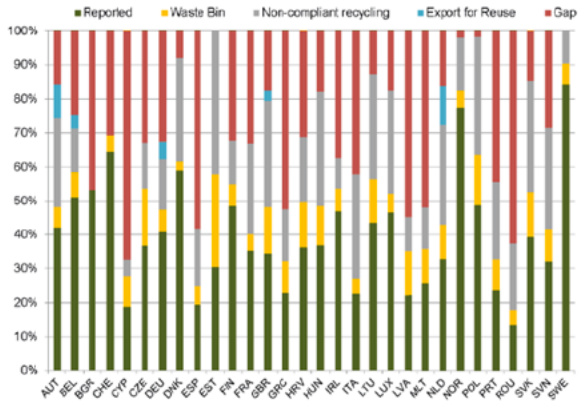


Figure 7: Waste Collection systems assessed, and good practices identified.
Source: COLLECTORS EU.

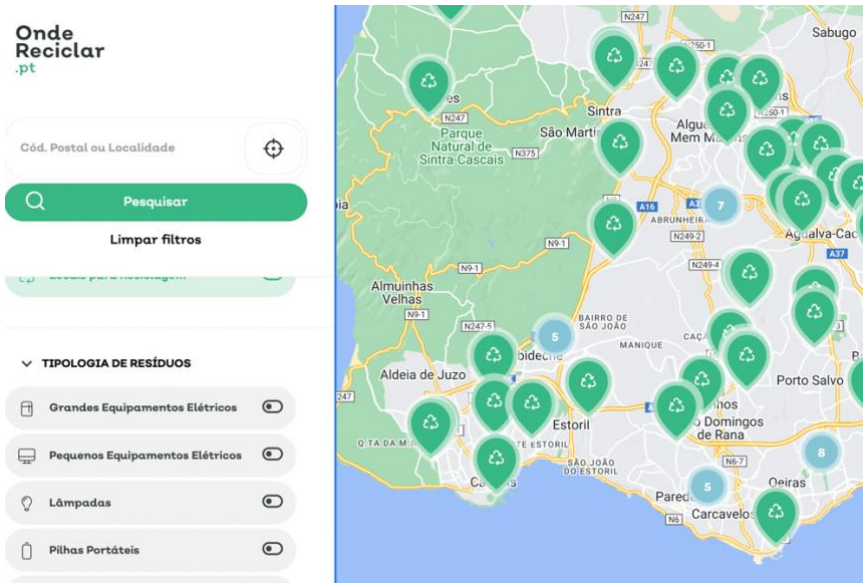
Furthermore, the disposal of waste is a critical factor since the waste which is not disposed of correctly is going not only to generate hazardous environmental effects, but also to be traded illegally. One of the biggest problems with illegal waste trading is that data are difficult to obtain since illegal WEEE exports could be mixed with metal scraps and transported using containers or vehicles (Olusegun Odeyingbo et al., 2020).

Going further with the normative legislation, Portugal still needs the 'all actors' approach and the requirement for WEEE handover. Nevertheless, Producer Responsibility Organizations (PROs) have openly supported these ideas and pushed for their implementation as essential policies in a future legislative amendment (Decreto-Lei n. º 102-D/2020). To have a general understanding of how consumers dispose of their domestic equipment in Portugal, Cascais municipality and Electrão's role are going to be analyzed. In general, Portuguese consumers have different disposal options. The first option available to the consumers, as in many European countries, is dropping off equipment when purchasing a new equivalent device, the so-called "*um-para-um*" (APA); however, there is also the option of handing in the old equipment without buying a new one, "*um contra zero.*"

The second option is to hand in the e-waste at the acceptance points. In this regard, PRO (Figure 8 & 9) may establish several agreements, such as the ones with *Centro comerciais, quartéis de bombeiros, scholas,* or *empress.* In this case, it has been shown the website of Electrão and how consumers, by selecting

the kind of e-waste they wish to dispose of, can choose the preferred dropping point. Not only acceptance points can be found through PROs but also at the Municipal level. Indeed, *Ambiente Cascais* has established twelve *ecocentric móveis*, and six *eccentric fixes*, giving a chance to citizens to dispose of their electronic appliances without needing to go to the recycling and disposal center (Figures 10). However, these points can accept only smaller appliances. Among many households' e-waste disposal path, in many exploratory studies in literature, it was found that consumers would prefer door-to-door waste collection (Corsini et al., 2020). Cascais municipality offers the service of door-to-door collection of large household appliances. The campaign is called "*a recolha de monstrous,"* meaning large household appliances. Consumers must call 48 hours in advance, and the municipality will arrive directly at the destination and pick up the waste. However, as explained by Chi et al. (2014), consumers need to be made aware of all the opportunities given to them by the companies involved in the process. Indeed, this campaign has a different effect than envisioned since more than half of the total collections made do not originate from an express request from citizens.

Therefore, more resources are spent, and abandoned waste stays longer on the public street or is picked up by illegal paddlers (Ambiente Cascais). Nonetheless, the results have been more than positive, respecting that before it was established. Another initiative which has been proposed, called "Porta a Porta" by Electrão and Lisbon municipality, has been showing great results. A pilot project started in 2021, intending to collect large households' WEEE directly at people's homes. Since the project started, already 100 tonnes have been collected (Electrão).



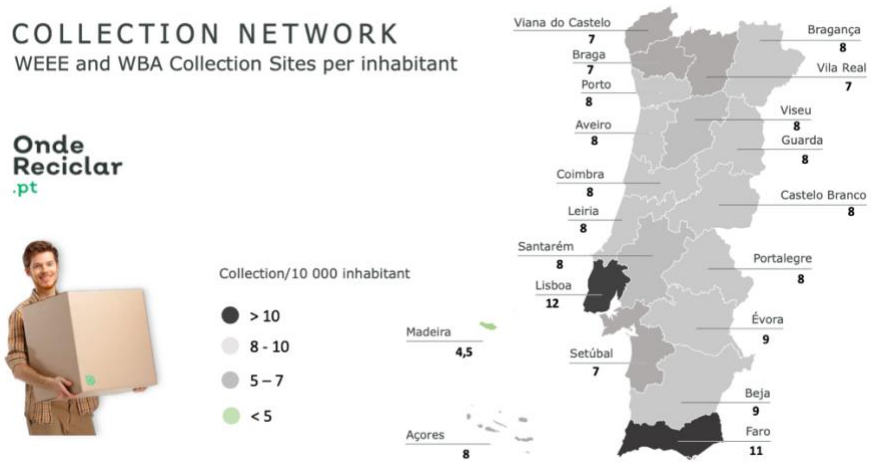


Figure 8 & 9: Collection points
Source: Electrão

Figure 10: Ecocentros Moveis
Source: Ambiente Cascais

Finally, in the literature, we find that one way to dispose of household appliances is by storing/ keeping behavior by consumers (Martinho et al., 2017). Indeed, as reported by many studies (Nowakowski, 2019), consumer tendency is to store small electric appliances, such as IT communications systems, rather than large home appliances; this is because it is more difficult to store more oversized items, and usually, they are going to be disposed of through informal or formal channels (Nowakowski, 2019). There are different reasons for storing behavior; among the most common, it is possible to find emotional attachment (Wieser & Troger, 2018). Another way to positively emphasize the correct disposal of the items is by analyzing the most common incentives given to citizens and discovering which one citizen prefers more.

2.2.3 Environmental awareness towards recycling household e-waste, with focus on Portugal

The biggest problem with consumers' hostile attitude toward e-waste concerns the need for environmental awareness that waste electrical and electronic equipment causes. According to Saphores et al. (2012), consumers in the United States are reluctant to transfer waste to appropriate recycling facilities, demonstrating

that this situation occurs in both underdeveloped and developed nations. People frequently hesitate to adopt ecologically friendly equipment because they need more information about the toxicity of e-waste. Lack of knowledge, inadequate information, and sociodemographic characteristics substantially impact customers' motivation to return e-waste in an e-waste take-back system (Botelho et al., 2016).

Recycling e-waste is necessary to comply with the circular economy model. Recycling e-waste can save precious materials that can be reused as copper, aluminum, gold, silver, and palladium. According to Unitar Global e-waste monitoring (2020), the gold content from e-waste was almost 300 tons, representing almost 12% of global production from mines. The recycling of these materials is, therefore, extremely significant. On the other hand, e-waste also contains toxic materials, such as lead, nickel, and flame reductants, which, if released into the environment, can damage human blood, kidneys, or the nervous system.

Additionally, toxic materials can seep into the ground and affect land, water animals, and all the people who live in the nearby areas, as is happening in Africa, India, or China, (Rautela et al., 2022) For these reasons, consumer awareness towards e-waste is going to be vital. If not, the consequences are several. Informal collectors and recyclers can get an advantage over this situation since, in some countries, people prefer selling their e-waste rather than recycling it (Islam et al., 2016).

Indeed, the unawareness causes some people to throw away their e-waste into the generic household bin. Citizenship's lack of awareness is also caused by the failed acknowledgment of national legislation (Cao et al., 2018). To increase consciousness, several authors have recommended setting up campaigns (Saritha et al., 2015). Indeed, this is a focal point. Specifically, in Portugal, PROs are obliged to devolve a part of their earnings towards the research, development, and education of citizens.

During these years, Electrão has established several awareness campaigns to help people understand the importance of separation of electronic materials. For instance, it has established an e-waste day on the fourteenth of October to raise awareness and track progress. Moreover, another initiative that the company started is "Faz pelo planeta." It is a mobilization program that, based on the promotion of waste recycling and circular economy, aims to inspire the different neighborhoods of Portuguese society to become agents of change, participating in the global movement to defend the planet. Regarding the municipality of Cascais, although in the past year has started some awareness campaigns in school or at the civil level, it has yet to begin a campaign towards EEE and WEEE.

In Portugal, also non-governmental organizations are active on this front, such as Assistencia Médica Internacional (AMI), Entreajuda, and Fundaçao do Gil (Marthino et al., 2017); but also APA with the recent initiative "Reciclar no Sentido Certo," aims to help citizens understand where to place electrical and electronic

equipment that can no longer be repaired and has reached the end of its life, and will raise awareness of the importance of one's behavior in the recycling process, leading him or her to follow only one direction: "the right one" (Direção-Geral das Atividades Económicas).

On the other side, ERP during the last years, being a PRO, has also contributed to exciting projects. Indeed, in collaboration with LG, Novo Verde, and the presentation, César Mourão, they surveyed citizens in Lisbon this year. They investigated inside people's houses' drawers and closets, looking for electrical and electronic equipment that was no longer useable or broken (César Mourão, ERP). Another campaign worth emphasizing is "Reciclar não tem História,"; a collaboration between EcoEscolas and ERP to encourage the delivery of small electrical and electronic equipment, which has reached the end of its life, demonstrating that this gesture can contribute to a more sustainable Planet.

2.3 Relevance of the study and Research Gap

The literature analysis reveals that many researchers have devoted their studies to the importance of e-waste management over the years. Indeed, e-waste management is one of the most pressing problems of modern society, which, if not resolved, can cause severe problems to human well-being. More specifically, a section that in recent years has gained attention in this area of research in consumer behavior, considered critical and essential (Saphores et al., 2012). Contrary to expectations, only a few countries (China leading the list) have examined consumer behavior as a factor of e-waste's impact, even though it may affect the environment in significant ways (Islam et al., 2021).

In general, most of the researchers which have focused in analyzing consumer behavior as an impact in e-waste management in a specific country, have focused their analysis on their understanding of specific areas of consumer behavior such as: knowledge or awareness about formal e-waste collection and recycling systems, storage behavior, disposal behavior, repair and reuse and recycling behavior. In addition, other than focusing on a specific area of consumer behavior, authors have studied specific issues that may affect their behavior. Moreover, few of these studies have taken into consideration all the categories of household e-waste; indeed, most of them have studied a specific waste stream and have analyzed the behavior of consumers related to that waste streams; IT and telecommunication equipment (Polak and dropalva 2012), small-electro domestics (Solé et al., 2012), or large appliances (Nguyen, D et al., 2009).

The aim of this research is to analyze firstly the current consumption, disposal, and awareness trends of Portuguese consumers over household e-waste, and secondly, wants to find out if these behaviors are associated with consumer sociodemographic characteristics towards consumption, disposal, and awareness. More precisely, the research questions which have been formulated are the following ones:

RQ1: What is the amount of household's electric and electronic equipment's and how much of these equipment's deserve effectively to be thrown away? Is consumption behavior associated with consumers' sociodemographic characteristics?
RQ2: What is the Portuguese consumers behavior towards the disposal of household's electric and electronic equipment's? Is disposal behavior associated with consumers' sociodemographic characteristics?
RQ3: Are Portuguese consumer environmentally aware to the importance of recycling household e- waste? Is awareness behavior associated with consumers' sociodemographic characteristics?

Consequently, the aim of this research is different from the previous ones, and it is relevant for many reasons. The first one is to contribute to an area of study which is considered deeply important, and which has not received much attention in the developed countries. Secondly, is to add another study in a country, Portugal, which has been studied so far. Indeed, the only two studies which are done towards consumer behavior on e-waste management is the one by Martinho et al., (2017), which analyzed the consumption, and disposal and tablets and smartphones, and the one by Célio Gonçalo Marques (2017), which analyses students' behavior in higher institutions regarding awareness and opinions on e-waste. Thirdly, by filling this gap and answering to the research questions, it is possible to contribute to the theoretical work already existing, and drawing some conclusions which can help companies, policymakers, and municipality to improve, and which categories of people need to be targeted to improve the collection rate of household e-waste.

For instance, some conclusions which can be derived from consumptions patterns can inform companies regarding products durability, recyclability, and repair options of household e-waste. Instead for disposal, companies can create interventions to promote responsible and environmentally friendly practices by understanding how consumers behave when it comes to using electric and electronic equipment. This can involve offering easy ways to recycle, offering rewards for responsible disposal, or launching awareness efforts to inform consumers of the significance of responsible disposal. Companies can also use this information to identify gaps in disposal processes and consumer barrier. This may involve offering simple recycling methods, rewards for responsible disposal, or launching outreach initiatives to inform consumers about the importance of responsible disposal. For what regards awareness, the government or companies can determine which consumer groups would benefit more from awareness campaigns or educational programs. This can help to better target communication methods and messages to engage and effectively reach various demographic groups, ultimately encouraging sustainable behavior and cultivating a feeling of environmental responsibility.

3. Research Methodology

This chapter offers a thorough breakdown of the study's research methods. In addition, it strives to improve comprehension and enjoyment of the research process while assuring the reliability and validity of the findings reported in this thesis by carefully outlining the study methodology, design, data collection methods, and analysis procedures.

3.1 Experts Interviews

Two experts were selected for an interview to have a better overview of the situation and factors which, according to them and their expertise, needed to be searched to have more significant results. The first expert is the CEO of one of Portugal's e-waste management companies. In his opinion, it is necessary to have a comprehensive overview of how Portuguese consumers recycle and dismiss their household e-waste because e-waste management companies want to help citizens recycle correctly. Moreover, according to this opinion, it can be useful to study how sociodemographic factors, such as education and employment, can be positively associated with consumers' consumption, disposal, and awareness behavior vs. household e-waste. In this way, targeted intervention can be made by policymakers to address specific needs.

The second expert who was interviewed works for Cascais Ambiente in the administrative office. In her opinion, among one the many reasons Portuguese consumers fail to dispose of their household items correctly is because the government and municipality need to implement other incentive measures to entice citizens, such as discounts or cash back systems, or maybe new take-ack systems for large equipment's.

3.2 Data Collection

The survey was conducted online and shared using snowball sampling as a method (Robson, 2002). Indeed, thanks to this method, people got the questionnaire through the university's association, university collogues, and social media and were encouraged to send the link to their network (Leighton et al., 2021). The survey was shared through a link and a QR code through these channels, trying to help respondents and save them time. Indeed, the questionnaire was conducted using Google Forms, a free online tool from Google that allows users to create surveys and collaboratively share the forms with others. For this empirical research, snowball sampling was adequate since it offered the advantage of quickly recruiting participants and reaching a significant pool of people from different geographical areas. It is inexpensive compared to other types of research (Marcus et al.,2017). In addition, for this explanatory research, the method will be effective since the aim is to get an overview of Portuguese consumers' behavior regarding e-waste consumption, disposal, and awareness. The survey was conducted anonymously to avoid negative social bias related to environmental subjects, and it was open from Saturday, 11th of March 2023, to the 11th of April 2023, and it reached 218 answers. All the answers have been reviewed and considered valid for the analysis. The questions are written following the literature and the suggestions made by the experts; indeed the content validity was checked by academic and professional experts in the field (Figure 12).

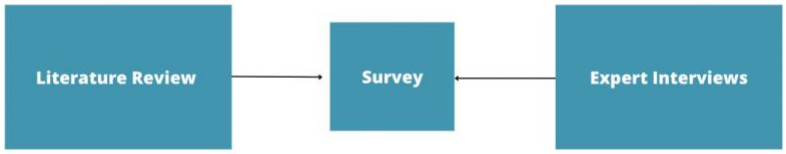


Figure 12: Survey construction

3.3 Questionnaire and Measures

The questionnaire presented a total of 23 questions, and it was administered totally in Portuguese to ease people understanding of the questions (Appendix B). It was divided into five parts. The first section was an introductory statement outlining the background of the study questions and the objectives of the respondents, which also guaranteed the data's privacy. The second part recalled seven sociodemographic aspects: Age, Gender, Education, Employment status, Family size, Location, and Family income. The other three parts have been structured to respond to each mini-research question constructed to understand the main research question.

The first six answers were grouped into the category *consumption*. The first three questions were grouped into four categories: IT & Telecommunication equipment, Consumption equipment, and small and large equipment. The aim was to find out how much of these were owned by the families, how many years they lasted, and how much of them were bought second-hand (Chi et al., 2014). These questions presented three ranges: 1-2, 3-4, >4. In addition, it was asked the reason for the equipment's substitution and the equipment's technical status at the time of the items' disposal (Marthinho et al., 2017). These questions are multiple-choice and qualitative.
Furthermore, the second six questions were grouped into the category *disposal*. The aim is to investigate the consumer tendency toward disposal behavior. More specifically, the first two questions in this group were aimed at understanding how respondents dispose of their small and large equipment. These questions are multiple-choice, and indeed, the respondent could choose from giving the item to the collection point, storing it at home, leaving it on the front door, or inside the mixed waste bin.

Then, the reason for storage was analyzed (Ylä-Mella et al., 2015 & Nowakowski, 2019); the answers were multiple choice also in this case, and the categories the respondent could choose from: do not care about the disposal, can be helpful in the future, it has sentimental value, or I have enough space at home to store it. Later, it was asked how much the responder knew about the different methods at the disposal of the Portuguese PROs, from 1 to 5, on a Likert scale. Then, it is asked if consumers would be more procreative in collecting household e-waste by door-to-door service, as was highlighted by the experts who were interviewed, but also

in the literature (Qu et al., 2019). Finally, it will be asked which kind of incentives are preferred (Shevchenko, 2019). The last two questions were as well multiple-choice questions.

In the last part of the questionnaire, the last five questions were meant to test consumers' behavior toward environmental *awareness.* All the questions were built using a Likert scale, from 0 (not aware) to 5 (completely aware). The first question was centered around the knowledge of the environmental damages that household e-waste possesses, such as lead, cadmium, mercury, and nickel (Parvez et al., 2021). The second one has centered around the knowledge of e-waste Portuguese and European law. The third one, instead, wanted to measure the awareness of valuable materials inside e-waste, such as gold, palladium, or copper (Yaashikaa et al., 2022); the fourth one is the knowledge of throwing the objects inside mixed e-waste bins, and the last one asked the importance of recycling (Ylä-Mella et al., 2015).

3.4 Pre-Processing

The survey was first pre-processed using Microsoft Excel and CVS. The pre-processing consisted of two main parts. The first part consisted of translating all the questions into English, and trying to abbreviate them, easing the data-processing part on R-studio. The second part consisted of checking among the answers that were given; there needed to be an answer because, in this way, other tests needed to be run. It is very often the case that a dataset needs to be fully completed or that there are missing values for various reasons, such as missing questionnaire responses. If the dataset contains missing values, R cannot apply the most critical functions, so investigations should be made. Whether the dataset is complete, otherwise appropriate adjustments should be made. As we can visualize in Figure 10, the dataset does not contain missing values when the graph has no yellow lines indicating missing values in the dataset.

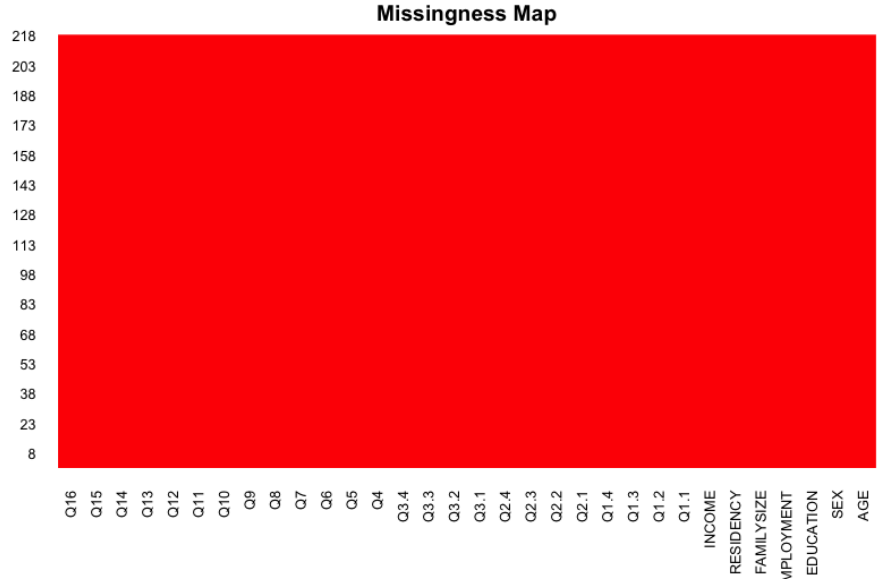


Figure 13: Missingness Map

3.5 Statistical Analysis

Statistical analysis was carried out using R-studio. The chi-square test is a statistical method utilized to determine the presence of a significant association between two categorical variables. It involves comparing observed frequencies with expected frequencies and aids in determining whether the observed data deviates significantly from what would be expected under a null hypothesis of no association (Field, 2013). It facilitates testing hypotheses, identifying patterns or associations of interest, and establishing relationships between variables. Assumptions of the chi-square test include categorical data, independent observations, and sufficiently large, expected frequencies in each contingency table cell. Reporting of chi-square test results includes the chi-square value, degrees of freedom, and associated p-value. A significant p-value ($p < 0.05$) indicates that the observed association between the variables is unlikely to have occurred by chance alone, suggesting a statistically significant relationship. Conversely, a non-significant p-value ($p > 0.05$) indicates insufficient evidence to reject the null hypothesis of no association (Field 2013).

This research aimed to test the dependence between the response variables, consumption, disposal, and awareness on sociodemographic variables, at a significance level of $p < 0,05$. The sociodemographic variables considered were sex, age, education, residency, employment, family income, and family size. Instead, as explained in the section above, the survey questions were grouped into three main groups: consumption, disposal, and awareness.

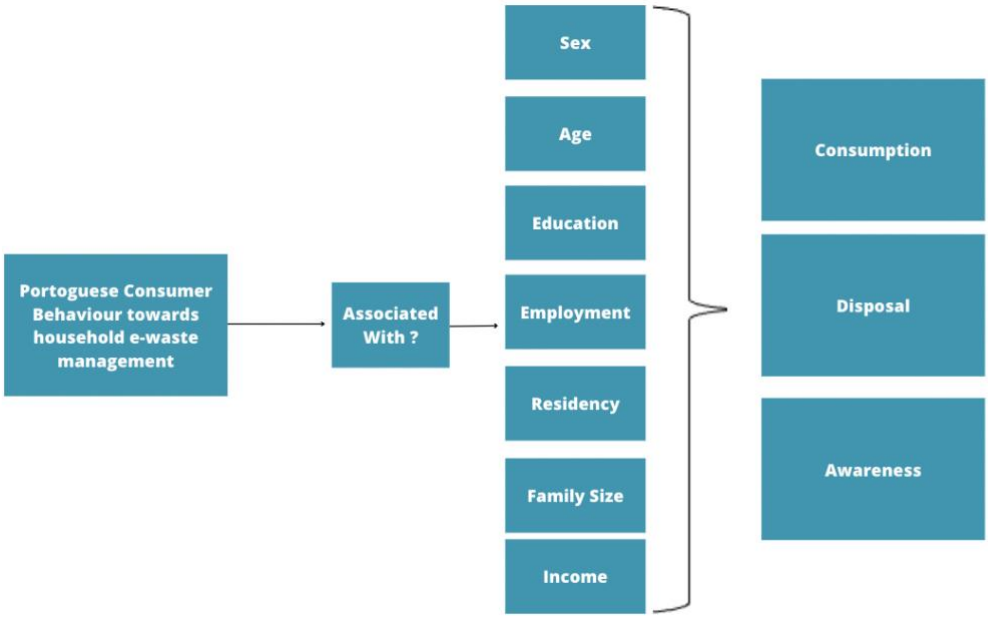


Figure 11: Developed Model

4. Findings

4.1 Descriptive Overview

4.1.1 Demographic Factors

A total of 218 people completed the survey. From the demographic data, 62 percent of all participants were female, 38 percent were male (See Table 1). Furthermore, regarding age distribution, the highest percentage is between 17 and 25 years old; the exact distribution by age group can be found in Table 1. The information regarding education status showed that 79% have university degrees, and 19% have high school degrees. Regarding employment, 35% are students, 44% are employed full-time, 8% are employed part-time, 11% are owners, and the rest are unemployed. Instead, for the family size, the highest distribution is held by families with 3 to 4 people (60%). Most people who answered the survey are from the Lisbon area (51%). The last question related to household income, the highest distribution is 29,4% between 10 and 20k, while the lowest is >60K with 7,3%.

AGE	#	%	SEX	#	%	EDUCATION	#	%	EMPLOYMENT	#	%
17-25	90	41,3	Woman	135	62	High School	47	21,6	Full-time	96	44,0
26-35	34	15,6	Man	83	38	University Degree	171	78,4	Part-time	17	7,8
36-50	31	14,2							Owner	24	11,0
>50	63	28,9							Student	75	34,4
									Unemployed	6	2,8
	218	100		218	100		218	100		218	100

FAMILY SIZE	#	%	RESIDENCY	#	%	INCOME	#	%
1-2	63	28,9	Grande lisbona	113	51,83486239	<10k	37	17,0
3-4	130	59,6	Norte	32	14,67889908	10-20k	64	29,4
>5	25	11,5	Sul	12	5,504587156	20-40k	82	37,6
			Centro	38	17,43119266	40-60k	19	8,7
			RA/ AZ, MD	7	3,211009174	>60K	16	7,3
			Algarve	9	4,128440367			
			Alentejo	7	3,211009174			
	218	100		218	100		218	100

Table 1 & 2: Sample Composition

4.1.2 Consumption Behavior

For what regards consumption behavior, the starting point is the number of items owned by Portuguese consumers. For what regards the number of IT and Telecommunication equipment, 38% of respondents have answered that in their household have more than four objects, 35% between 3 and 4, while the rest between 1 and 2. In addition, regarding consumption equipment, such as TVs', 45% of the respondents have more than 4, and just 24% have between 1 and 2. Instead, regarding little electro domestics such as iron or vacuum cleaner, 45% have more than 4 items insider their households, 29% has between 3 and 4, while the rest between 1 and 2. Finally, for what regards big EEE, 45% has more than 4. Moving on, for what regards the number of EEE which are presents inside the household and are bought second-handed, in the four categories explored the percentage of people who has never bought second-handed items is always higher than 50%. However, people who bought between 1 and 2 second-handed items are more than 25% in all the categories. Regarding the years that pass before substituting an item, it is possible to see that for the categories of consumption and large equipment, more than 75% of respondents change it after 4 years. Instead, for what regards IT equipment, after 3 to 4 years (42%), instead little EEE after 3 to 4 years (48%). For what regards the reasons for substituting the equipment, 80% of the respondents, changed it because it was broken, while the rest for a new model. Lastly, when asking about the alternative solution to a broken item, 36% of the respondent repair it because it costs less, 32% would buy a new one for a discount, 18% would buy the latest model, 14% would repair it (Appendix A).

4.1.3 Disposal Behavior

For what regards the disposal behavior, most people of store it at home (44%) and give it to formal collection point (47%); the minority put it in the mixed waste bin (6%) or leave it to the front door (3%). For what regards large equipment disposal, most people (63%), give it to formal collection points, while in this case 19% of people leave it to the front door, 15% store it at home while the rest insert it in the mix waste bin. The reasons for storage differ; however, the bigger trend (48%) is that people believe it is useful for the future (48%), 24% does not care about the disposal, 21% nurture a sentimental value on its behalf and the rest do not have space issues. In such it is possible to see that a very high percentage of people still do not dispose of their e-waste but prefer to store it inside their household for different purposes. Regarding the knowledge of the Portuguese PROs, 33% has a full knowledge, 27% medium knowledge, and the rest little knowledge. For what regards the possibility of door-to-door collection organized by municipality at least once per month, 59% find the organization functional and useful, 34% said it is useful because they do not have to go the collection points. Lastly, for what regards the preferred incentives methods, most Portuguese citizens (36%) preferred to have a discount when buying a new green item, 35% would prefer a cash-back incentive system, just a minority (19%) do not care about the incentive but care about the environment, and the rest wish to have tax discount (Appendix A).

4.1.4 Awareness Behavior

Regarding Awareness Behavior, 42% of the respondents are fully aware of toxic materials inside electric and electronic appliances, 30% are moderately aware, 13% are aware, and the rest are not aware. Instead, regarding the awareness of Portuguese and European law regarding electric and electronic appliances, 65% of the respondents need to be made aware, and only 6% of them are fully aware. In addition, the knowledge of the valuable materials that can be found inside the electric and electronic appliances, 36% are fully aware, 22% are moderately aware, 28% are aware, and 11 % are not aware. Moving on, regarding the awareness of the effect of throwing electric and electronic appliances inside the mixed waste bin, 29% are fully aware, 25% are moderately aware, 26% are somehow aware, and 20% are not aware. Lastly, regarding the importance of recycling, 49% are fully aware, 33% are moderately away, 13% are somehow aware, and the rest are unaware (Appendix A).

4.2 Statistical Analysis

As explained in section 3.5, a statistical analysis was performed to determine the association between sociodemographic characteristics, sex, age, education, employment, family size, residency, and income. The result of the chi-square test analysis can be found from Table 3 to 5.

4.2.1 Consumption Behavior

The result of the analysis between consumer behavior and sociodemographic characteristics can be seen in Table 3. Regarding possession of electric and electric appliances (Q1), age, employment, family size, and income are significantly associated. More in detail, for what regards the possession of IT and telecommunication equipment (Q1.1), such as cellphones and PCs, households with younger respondents (17 to 25) show to have more items concerning older respondents (p-value 0.000). This is also true for family size; indeed, the more household presents family members, the more equipment it possesses; families with 3 to 4 family members possess more than four pieces of equipment (p-value 0.000).

Regarding (Q1.2), the possession of consumption equipment, such as TVs, is highly influenced by age (p-value 0.0156) since older respondents expressed higher ownership levels, respect than middle-aged respondents, and also by income (p-value 0.012) since people with income between 20/40K answered to have more from 3 to 4 equipment in their household, respect than people with lower income, which expressed to have from 1 to 2 equipment. Regarding small electronic appliances, such as iron, and vacuum cleaner, respondents 36 years old mostly expressed their possession of >4 (p-value 0.21); instead, talking about income levels, people with higher income have more than 4 equipment, while lower levels, tend to own 1 to 2 items. The same association can be found for large equipment (Q1.4).

An exciting aspect is to look for the number of numbers of equipment that are second-handed. Regarding the number of it and telecommunication equipment (Q2.1), age, employment, and income are associated. Respondents aged between 17/25 showed more willingness to buy second-handed It/telecommunication equipment than older respondents (p-value 0.008). Also, students, among all the other categories of employment type, showed to be more willing to buy second—handed equipment. Moving on (Q2.2), talking about consumer equipment, the higher tendency to buy second-handed items is the unemployed and then owners (p-value 0.000). The sample applies (p-value 0.030) in households with 1/2 members, which showed a higher tendency to buy second-handed equipment. Instead, regarding the consumption of small second-handed equipment (Q2.3), we can see that the trend still applies. Student and unemployed people tend to buy more second-handed than the other categories, and full-time workers, instead, highly prefer to buy new products instead of second-handed ones.

For what regards the reason for substation (Q4), it is possible to see that although the higher tendency is to buy a new item because the latest is broken, the higher category which wished to buy the latest model is over 50 years of age, and between 26 to 35 years old (p-value 0.001). Analyzing instead the solutions that one can encounter when repairing household equipment, it is possible to see that younger respondents prefer to buy a new one for a discount or repair because it costs less. In contrast, those from 26 to 50 years prefer to buy it for a discount, while over 50 repairs because it costs less (p-value 0.41). Instead of analyzing the level of education, it is possible to see respondents whose high school achievements prefer to repair the item because it costs less or because they like it. In contrast, university graduates prefer to buy a new one for a discount or repair because it costs less (p-value 0.023). Lastly, regarding income levels, it is possible to observe that while categories under 20K prefer to repair the items because they cost less, categories over 20K prefer to buy them for a discount or buy the latest model (p-value 0.028).

		SEX	AGE	EDUCATION	EMPLOYME	FAMILY SIZ	RESIDENCY	INCOME
Q1.1	X-squared	1,01	30,28	9,25	40,24	31,73	11,35	37,37
	p-value	0,604	0,000	0,055	0,000	0,000	0,499	0,000
Q1.2	X-squared	1,40	18,85	7,77	39,67	32,31	11,35	37,37
	p-value	0,497	0,016	0,101	0,00	0,00	0,50	0,00
Q1.3	X-squared	1,01	17,94	13,35	22,51	24,17	19,55	36,34
	p-value	0,604	0,022	0,010	0,000	0,002	0,499	0,000
Q1.4	X-squared	2,32	25,55	5,12	21,37	31,85	15,76	35,67
	p-value	0,313	0,001	0,276	0,045	0,000	0,202	0,000
Q2.1	X-squared	1,07	23,48	7,79	65,19	6,75	19,98	25,14
	p-value	0,784	0,024	0,254	0,000	0,874	0,334	0,048
Q2.2	X-squared	1,51	19,01	1,74	134,50	22,74	56,83	12,84
	p-value	0,680	0,088	0,942	0,000	0,030	0,000	0,615
Q2.3	X-squared	11,83	10,73	6,66	93,74	13,67	11,10	14,43
	p-value	0,008	0,553	0,354	0,000	0,322	0,890	0,493
Q2.4	X-squared	0,61	10,17	28,91	69,55	8,30	12,99	15,02
	p-value	0,894	0,601	0,000	0,000	0,761	0,792	0,450
Q3.1	X-squared	0,09	23,62	20,56	42,79	22,84	40,52	15,18
	p-value	0,956	0,003	0,000	0,000	0,004	0,000	0,126
Q3.2	X-squared	2,11	40,26	8,62	71,69	28,27	28,62	21,80
	p-value	0,347	0,000	0,071	0,000	0,000	0,004	0,016
Q3.3	X-squared	3,35	22,17	2,55	42,86	14,75	34,10	10,07
	p-value	0,187	0,005	0,635	0,000	0,064	0,001	0,435
Q3.4	X-squared	0,83	34,29	6,31	34,64	12,85	51,74	9,92
	p-value	0,661	0,000	0,177	0,001	0,117	0,00	0,447
Q4	X-squared	2,86	26,10	2,41	35,79	24,82	42,91	10,46
	p-value	0,239	0,001	0,661	0,000	0,002	0,000	0,401
Q5	X-squared	0,14	21,64	14,66	36,38	31,73	13,93	27,06
	p-value	0,987	0,042	0,023	0,006	0,000	0,733	0,028

Table 3: Chi-square test, Consumption Behavior

4.2.2 Disposal Behavior

Regarding the disposal behavior and the association between sociodemographic variables, the results can be found in Table 4. Regarding the disposal of small household appliances, age, education, family size, and income played an essential role in the association. Indeed, older respondents (>50) tend to store small items, while younger respondents wish to give them to formal collection points (p-value < 0.000). In addition, respondents with higher members in the household show the tendency to store smaller household EEE rather than households with fewer household members (p-value 0.000). Furthermore, households with more than 40K shown for the majority to give small e-waste to formal collection points, while households with less are prone to either throw them into a mixed waste bin or store it at home (p-value 0.002).

Moving on with the disposal of large household appliances, age, employment, family size, residency, and income played an essential role in the association. Regarding age, people over 50 tend to leave the items in front of the door and store them, rather than younger respondents (p-value <0.000). Regarding employment, respondents who are students for the majority throw the items into formal collection points, while unemployed, part-time ad owners tend to leave items in front of the door. At the same time, full-time workers usually give the items to formal collection (p-value <0.000). Regarding the household members, instead, households with

more than three family members show a tendency to give the items to the formal collection rather than those with less than 3 members (p-value <0.000). People from the south of Portugal tended to leave large items in front of the door or store them at home rather than the ones from the center and north (p-value 0.009). Finally, households with higher income tend to give the items to the formal collection rather than those with lower income (p-value 0.003).

Moving on, analyzing the reason for storage, it is possible to observe that age, employment, and family size impact intensely. Indeed, people who are over 50 years of age store it because they believe that the items are helpful for the future and respect that; for instance, from 26 to 35 do not care about disposal (p-value 0.022). Regarding employment, owners tend to store the items for sentimental value. At the same time, students and full-time workers prefer to store them because they think it is helpful for the future (p-value 0.016). Lastly, respondents with a household between 1 to 2 people think of disposing of the item because they believe it is helpful for the future. In comparison, people with a household of 3 to 4 people do not care about the disposal or believe it is helpful for the future. Moving on, regarding the knowledge of PROs, family size and residency play an essential role. Respondents with families between 1/2 have less knowledge than those with families of more than four members (p-value 0.030). Lastly, people from the north and Lisbon areas expressed more knowledge of PRO than those from the south (p-value 0.039).

Finally, age, employment, and residency are associated with the preferred incentive methods. Indeed, respondents >50 have expressed interest in more cashback positions and discounts for new green items. In contrast, younger respondents answer that they care about the environment and wish to have tax discounts. Respondents aged 36 to 50 also expressed their interest in a discount for a new green item (p-value 0.001). Instead, respondents with full-time positions expressed interest in discounts with new green items. In contrast, students who preferred cashback were unemployed and retired and expressed their interest in the environment (p-value 0.003). Regarding the residency area, most people from Lisbon surroundings prefer a discount for a new green item, while people from the north and center wish to have cash back (p-value 0.007).

		SEX	AGE	EDUCATION	EMPLOYMENT	FAMILY SIZE	RESIDENCY	INCOME
Q6	X-squared	1,52	78,31	20,79	22,85	38,40	20,30	35,41
	p-value	0,678	0,000	0,002	0,196	0,000	0,316	0,002
Q7	X-squared	2,22	121,69	12,04	64,52	84,60	43,02	41,41
	p-value	0,695	0,000	0,150	0,000	0,000	0,010	0,003
Q8	X-squared	1,76	23,63	4,85	33,10	21,34	21,99	24,53
	p-value	0,623	0,023	0,563	0,016	0,046	0,233	0,057
Q9	X-squared	0,95	9,75	7,80	26,74	28,09	37,45	25,21
	p-value	0,918	0,879	0,453	0,317	0,031	0,039	0,193
Q10	X-squared	5,92	20,18	2,91	17,80	18,18	15,19	11,56
	p-value	0,116	0,064	0,820	0,469	0,110	0,649	0,712
Q11	X-squared	1,94	32,11	5,47	38,10	19,39	35,88	15,31
	p-value	0,585	0,001	0,485	0,004	0,080	0,007	0,429

Table 4: Chi-square test, Disposal Behavior

4.2.3 Awareness Behavior

For what regards awareness behavior, the results are shown in Table 5. It is possible that for what regards the awareness of the toxic elements that can be found inside electric and electronic appliances, education and family size played an important role. Indeed, regarding education (p-value of 0.02), people with university degrees are more knowledgeable respect than people with high school degrees. Instead for what regards family size (p-value 0.018), respondents with a household composed of between 3 to 4 members have more knowledge regards the toxicity levels concerning 1 to 2 members, for instance.

Moving on, regarding the knowledge of EU and Portuguese legislation of e-waste, age, education, employment, family size, and residency showed an association. Indeed, lower knowledge has been associated with people between 17 and 25, for 36 to 50 (p-value <0.000). Regarding education (p-value 0.013), people with university degrees generally showed more knowledge and respect than those with high school degrees. In addition, full-time respondents showed more knowledge regarding e-waste laws and respect than students (p-value 0.001). Lastly, people the Lisbon and the center of Portugal have shown more knowledge and respect for other areas (p-value of 0.041).

Instead, regarding the awareness of valuable materials in electric and electronic appliances, age, employment, and residency are associated. Younger respondents are more aware than older respondents (p-value 0.005). Full-time respondents are more aware of respect than unemployed or owners (p-value 0.040). People from Lisbon and the north of Portugal are more aware than people from the South (p-value 0.012).

Moving on, regarding the awareness of the effects of throwing household e-waste inside the mixed waste bin, it is possible to observe that age, education, and income are associated. Younger respondents are more aware of the effects rather than older respondents (>50) (p-value <0.000). University degree respondents are more aware of respect for high-school respondents (p-value <0.000). Regarding income level, respondents with a household income higher overall than 20K showed a higher awareness respect than lower levels (p-value 0.015).

Finally, the importance of recycling impacted sex, age, and residency. Women showed more willingness to recycle and separate e-waste respect than men (p-value 0.032). This is true also for younger respondent's respect than older respondents (p-value 0.015), and people from central Portugal and the Lisbon area (p-value 0.040)

		SEX	AGE	EDUCATION	EMPLOYMENT	FAMILY SIZE	RESIDENCY	INCOME
Q12	X-squared	2,66	17,97	17,88	34,43	29,92	33,29	28,93
	p-value	0,616	0,326	0,022	0,077	0,018	0,098	0,089
Q13	X-squared	1,84	58,67	19,24	50,74	19,39	37,23	21,87
	p-value	0,765	0,000	0,014	0,001	0,080	0,041	0,347
Q14	X-squared	5,55	34,21	11,15	37,31	24,63	42,25	18,06
	p-value	0,235	0,005	0,193	0,041	0,077	0,012	0,584
Q15	X-squared	8,25	46,75	21,30	32,09	22,67	29,45	36,07
	p-value	0,083	0,000	0,006	0,125	0,123	0,204	0,015
Q16	X-squared	10,49	30,44	5,59	20,12	14,48	37,07	21,34
	p-value	0,033	0,016	0,693	0,690	0,563	0,043	0,378

Table 5: Chi-square Test, Awareness Behavior

5. Discussion and Recommendation

This research was dictated to determine if Portugal's low household e-waste collection rate is associated with consumer sociodemographic characteristics towards consumption, disposal, and awareness. An investigation was carried out with a questionnaire, investigating the three main groups of variables: consumption, disposal, and awareness, and their association with sociodemographic variables using a statistical analysis of the chi-square test.

5.1 Consumption

First, it is possible to confirm that, as in literature (United Nations e-waste monitoring), also for Portuguese consumers, large equipment and temperature exchange equipment are present in each household from 4 onwards. This implies a relevant entry into the market towards the consumption of these appliances. This is also in line with market forecast trends (Statista N2), which show how much the increase in revenue from selling this suppliance increase, and with environmental research that shows how much cooling and freezing equipment are bought for a physical necessity. However, they can harm our planet and generate CO2 emissions (Coulomb, 2023). With regards to small equipment instead, households with higher family members possess more items and respect than those with fewer.

An interesting aspect is that younger respondents possess and consume much more items than older respondents. As such, universities and high schools should adopt more proactive strategies to make students understand the harm of impulsive buying of IT and telecommunication equipment. It is imperative to focus on education for this age range to push the importance of the uselessness of compulsive consumption and purchase of IT and telecommunication equipment. The same reasoning can be applied to the other categories, such as consumption (TV) equipment or small equipment, where age and income are significantly associated.

An exciting observation is how many people have bought their household equipment secondhanded instead of buying it new. Although most respondents prefer to buy new household electric appliances, there is a non-

indifferent percentage (25%) in each category analyzed of consumers who prefer to buy second-handed items. Especially this data has been associated with students in the IT and Telecommunication equipment category. This data can be confronted with the fact that students prefer to buy them more; however, some are environmentally aware of the benefits of buying them secondhand. Altogether the universities and high schools should push the benefits of buying second-handed equipment. This observation was also seen in owners and unemployed people. This can be a good sign that there are categories keener on buying second-handed equipment, and if implemented at the national level can reach more than positive results since owners represent a significant percentage of the employment in the country.

Regarding the reasons for substitution, Portuguese consumers seem environmentally friendly since they prefer buying new equipment when the other one breaks. Also, when it breaks, it is possible to say that there is a minority of people who will buy them because of the latest model, or indeed the category with higher income and the older people. Indeed, a plausible explanation can be related to the GDP trends. The late recession (2020/2022) hit hard on Portugal, which was on the verge of recovering from the last one (2008/2011), and indeed it lowered purchasing power of citizens (OECD, 2022).

Several recommendations can be made regarding these points. First, Policymakers can encourage sustainable consumption patterns through awareness campaigns, rewarding repair services, and promoting the purchase of energy-efficient and long-lasting products given the high ownership rates and regular replacement of equipment (Bocken et al., 2016). This can lessen consumer behavior's environmental impact and assist reduce electronic waste. Secondly, to promote second-hand market as a viable and affordable alternative, policymakers can work with industry stakeholders, to adopt model such tax incentives or subsidies for used goods, with the aim of persuading consumers to adopt a circular economy model (Gregson et al., 2015). The second-hand market represents a great opportunity also for companies, which can develop strategies to tap into this consumer segment. In addition, companies may consider offering smart repairing services, in this way it will make easy to repair the item, instead of buying a new one (Maleki Vishkaei Behzad et al., 2022).

5.2 Disposal

As the literature confirms (Nowakowski, 2019), most Portuguese consumers store small items at home. In this regard, students have shown to be more proactive towards throwing them into the formal collection points. One plausible explanation can be related to the fact that there are present disposal points through universities in Portugal, such as the one that Cascais Ambiente is trying to install around the cities. This result suggests that disposal points around sites such as universities and cities are a good option. Indeed, it is suggested to insert more of these disposal options around the cities and in the workplace. However, the storing behavior shows a lack of awareness of the impact of retaining items inside one’s household, meaning that much work needs to be done to increase awareness (Do Valle, P. et al., 2004).

Regarding the disposal of large items, there is a tendency to bring the items into the formal collection systems. At the same time, the rest of the population leaves them in front of the door or stores them—especially people over 50 and people from the South of Portugal. The concern aroused by the interviewed Cascais employee regarding the fact that the municipality picks up e-waste on the street is also confirmed in the questionnaire since almost 20 percent of respondents answered that they tend to leave the waste in front of the door without calling the appropriate number. This means that the initiatives adopted so far are not as efficient as expected.

Regarding the reason for storage, it is confirmed that most respondents believe that the item can be helpful in the future, leading to a waste of resources and contributing to environmental problems such as increased carbon emissions, pollution, and landfill waste. Saphores et al. (2012) suggested how in the US, the convenience and the knowledge of recycling facilities helped to increase the collection rate. In the questionnaire, it was asked if respondents knew all the disposal options provided by the PRO. Just (33%) were fully aware of that. Indeed, respondents from the Lisbon area are more knowledgeable than others. This means that PROs with the municipality should do a better job of increasing awareness of disposal sites and encouraging people to dispose of the items correctly. A recommendation for PRO is to create more convenient collection points, more people will be enticed to properly dispose of their e-waste instead of keeping it at home or using improper disposal techniques (Botelho A. et al., 2016). In addition, older respondents vs. younger prefer to store instead of disposing the items, since they believe it may be useful for the future, causing the necessity of tailoring messages about the significance of proper e-waste disposal to different age groups. Moreover, E-waste disposal behavior is influenced by household income, with higher-income households being more inclined to submit their electronic garbage to designated collection sites. This emphasizes how crucial it is to give all socioeconomic groups equal access to appropriate e-waste disposal solutions (Thi Thu Nguyen et al., 2018).

It was asked how consumers appreciate the door-to-door collection method. It was discovered that all the respondents felt that it is helpful because they either do not have to go to the collection point or because it is functional and practical. This aligns with the literature (Corsini et al., 2020) but also shows how the municipalities should better implement the model. Indeed, this shows that citizens would like the government or municipalities to implement this initiative. The suggestion which can be made are two: The first one is to establish a day in a month in which the municipality, in agreement with the PRO, go around and pick up household appliances. It would be ideal to start with large heavier appliances to see how consumers react since they are bulkier and heavier. The second suggestion is to pick it up and avoid the 48h call before because it could be inefficient, and if people leave the materials on the street, scrappers or other people could take them.

According to research, financial rewards provided by the government or the manufacturer to consumers who return end-of-life products to authorized recyclers encourage people to participate in the treatment of e-waste.

Indeed, among the favorite option for Portuguese consumers, there would prefer a discount on new-green items, which shows firstly that Portuguese consumers are aware of the importance of buying new green items which consume less and waste less energy. This is true, especially for a full-time employee. Secondly, they appreciate cash back, especially students and the unemployed. Giving incentives can be the right strategy to foster proper household disposal and should be further implemented (Shevchenko, T., Laitala et al., 2019).

5.3 Awareness

Talking about the level of awareness of Portuguese citizens towards toxic materials inside e-waste, it is possible to observe that the results align with the study made by Martinho et al. (2017). In that case, the analysis focused only on smartphones and tablets. The level of awareness is an accurate indicator since it helps understand whether consumers have enough knowledge to dispose of their household e-waste accurately (Botelho et al., 2016). In this regard, Portuguese citizens have a moderate understanding, which can undoubtedly be increased. Especially the result is linked to the educational background, meaning that the more the respondents are educated, the more they are aware.

An interesting aspect to notice is that consumers are more aware of the toxic elements contained inside household e-waste rather than potential materials which can be reused. An observation can be made that citizens are more concerned regarding toxicity than the reuse level. For instance, the health risks associated with toxic materials inside e-waste are more documented than the potential for reuse; their risks outweigh the benefits. In addition, since younger people are more aware, it can be possibility to involve and empower young people in environmentally friendly practices and projects (Johnson, B., & Činčera, J. 2015). Moreover, regional differences in awareness, such as the greater awareness in Lisbon and the northern part of Portugal, underscore the necessity of tailored interventions in places with lower awareness. These interventions include localized awareness campaigns, educational initiatives, and infrastructure development for ethical e-waste disposal.

The results also align with the awareness of throwing household e-waste inside the mixed waste bin. The ones who are aware of the toxicity levels of e-waste are also aware of the implication of throwing them inside mixed waste bins. This result is also associated with income level and age, showing how more educated and prosperous respondents are more aware of the harm this behavior causes.

The results show a low knowledge of National and European legislation. There is the need for government to enhance efforts in communicating these laws, potentially through educational campaigns. One implication of inadequate expertise can lead to citizens not understanding the role of PROs and not helping the system towards a suitable collection scheme.

Finally, regarding the level of awareness of knowledge, a significant portion of the Portuguese population needs to be fully aware of the importance of recycling household e-waste. In addition, women are more knowledgeable than men about the importance of recycling. Indeed, according to a study by White et al. (2016), women are more likely than males to recycle because they are more likely to be driven by social standards and adhere to group values. Moreover, Given the correlations between awareness levels and income, it is possible to apply financial incentives or legislation to promote correct disposal and recycling practices. This can entail putting in place rules that make improper disposal more expensive or providing incentives for the collection and recycling of e-waste.

6. Conclusion

This research paper tried to investigate if the low household e-waste collection rate in Portugal can be attributed to consumer behaviors. For this reason, it analyzed consumer behaviors toward consumption, disposal, and awareness of household e-waste. A survey was administered online to carry out the study, and the results were analyzed first from a descriptive point of view and second from a statistical point of view with a Chi-square statistical analysis. The conclusions that have been made are the following ones:

- Large and temperature exchange equipment are commonly found in Portuguese households from 4 onwards, aligning with market forecasts and environmental research on the necessity of cooling and freezing equipment.
- Younger respondents tend to possess and consume more IT and telecommunication equipment, highlighting the need for proactive strategies in educational institutions to raise awareness about the negative impact of impulsive buying.
- Age and income are significant factors associated with TV consumption and small equipment, emphasizing the importance of tailored approaches to address these demographics.
- A substantial percentage (25%) of consumers, particularly students, opt to purchase secondhand household equipment, indicating a growing awareness of the environmental benefits of buying used items.
- Policymakers can promote sustainable consumption patterns through awareness campaigns, incentivizing repair services, and advocating for the purchase of energy-efficient and long-lasting products.
- Collaboration between policymakers and industry stakeholders can further promote the secondhand market by implementing tax incentives or subsidies for used goods, fostering a circular economy model.
- Companies can tap into the secondhand market by developing strategies to cater to this consumer segment, such as offering innovative repairing services to encourage item repair instead of immediate replacement.

- Disposal points around universities and cities prove to be effective in encouraging proactive disposal behavior among students.
- Increasing the number of convenient disposal options around cities and workplaces is recommended to improve disposal rates.
- Respondents need more awareness about the negative impact of storing items at home, leading to resource waste and environmental problems.
- Proper awareness campaigns are necessary to educate the public about disposal sites and encourage correct e-waste disposal.
- Tailoring messages about the significance of proper e-waste disposal to different age groups is crucial, especially for older respondents who tend to store items.
- All socioeconomic groups should have equal access to appropriate e-waste disposal solutions.
- Consumers appreciate door-to-door collection methods as they are convenient and practical, indicating the need for better implementation by municipalities.
- Establishing regular collection days for household appliances and avoiding needing a 48-hour call can improve efficiency and prevent scavenging.
- Financial rewards and incentives, such as discounts on new green items, encourage participation in e-waste treatment and should be further implemented.
- The level of awareness among Portuguese citizens regarding toxic materials in e-waste is moderate and can be increased, particularly among more educated individuals.
- Citizens are more concerned about the toxicity of e-waste than its potential for reuse, highlighting the need for awareness campaigns focusing on both aspects.
- Tailored interventions, localized awareness campaigns, education initiatives, and infrastructure development are needed in regions with lower awareness levels.
- Greater awareness of the harmful effects of throwing e-waste in mixed waste bins is observed among more educated and prosperous respondents.
- Knowledge of National and European legislation regarding e-waste disposal could be higher, emphasizing the need for improved communication and educational campaigns.
- Increasing awareness among the Portuguese population, especially women who are more likely to recycle, can be achieved through financial incentives and legislation.
- Proper disposal and recycling practices can be promoted through measures that make improper disposal more expensive or provide incentives for collection and recycling.

6.1 Limitation

It is important to acknowledge the practical limitations of this research paper. The potential for generalizability restrictions is one potential issue that may develop in research studies with fewer participants than the actual

population. While it is true that smaller sample sizes may restrict a study's statistical power and make it more challenging to find meaningful associations or effects, it is crucial to remember that there can also be advantages to doing research with smaller sample size. For instance, studies with a smaller sample size can enable more thorough evaluations of individuals. These studies can also be beneficial for formulating initial hypotheses or examining innovative research problems. Additionally, even with smaller sample sizes, statistical technique has been used to guarantee that their findings are as accurate and dependable as possible. While small sample sizes may present some difficulties, they can tremendously influence the carrying out of worthwhile and significant research. Another potential limitation which can be encounters in this research is although snowball sampling was used to share the survey, the backgrounds of the respondents is similar and is surrounded in the university area. In such, it can be argued that the results may not represent perfectly all the backgrounds all population has. However, the results are still valid although they represent a narrow segment.

6.2 Suggestion for future research

In conclusion, several suggestions for future research can be made. To better understand how consumers dispose of specific e-waste categories, future research could explore one single category. In this way, considering a category or appliance (e.g., washing machine), even more specific results can lead to the strategic implementation of educational campaigns based on awareness and prevention of wrong behaviors from Portuguese citizens. The second suggestion is to strongly try to expand this research towards a national scale and get more results from the consumers. To achieve such results, several approaches can be taken. The same survey can be expanded by age categories; for instance, it can be distributed to high school students and universities, then for older-age ranges, electronic distributors and shops or disposal sites can be encouraged to share the survey. By implementing these two suggestions, more specific results can be obtained, which aim to understand the reasons driving their consumption, how they are disposed and awareness.

Moreover, a new study can be done on the long-term impact of awareness campaigns and incentivization programs on the sustainable consumption of household EEE and e-waste disposal of Portuguese citizens. This study can provide relevant insights regarding the effectiveness of different interventions over time. In addition, more profound research can be done on the socioeconomic disparities found in household e-waste management to understand the issues that marginalized or poorer communities face and to implement inclusive strategies. Furthermore, it can be analyzed the effectiveness of repairing services offered in Portugal; in this way, it is possible to understand the consumer’s attitude on these points and their contribution to reducing household e-waste generation. Finally, research can be done to determine the extent to which Portuguese consumers are aware and comprehends national and European laws about the disposal of e-waste, to ensure greater compliance with e-waste legislation, identify knowledge gaps and propose methods to increase communication and educational efforts.

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Appendix I: Categories of Electric and Electronic Equipment covered by European Directive.

1. Temperature exchange equipment

2.Screen, monitors, and equipment containing screen having a surface greater than 100 cm2

3. Lamps

4. Large equipment (any external dimension more than 50 cm) including, but not limited to:

Household appliances; IT and telecommunication equipment; consumer equipment; luminaires; equipment reproducing sound or images, musical equipment; electrical and electronic tools; toys, leisure, and sports equipment; medical devices; monitoring and control instruments; automatic dispensers; equipment for the generation of electric currents. This category does not include equipment included in categories 1 to 3.

5. Small equipment (no external dimension more than 50 cm) including, but not limited to:

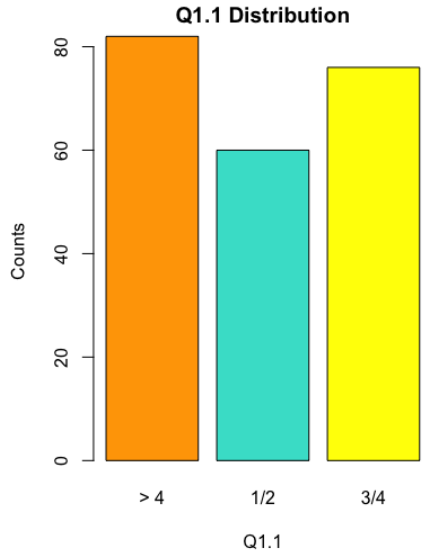
Household appliances; consumer equipment; luminaires; equipment repro- ducing sound or images, musical equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments; automatic dispensers; equipment for the generation of electric currents. This category does not include equipment included in categories 1 to 3 and 6.

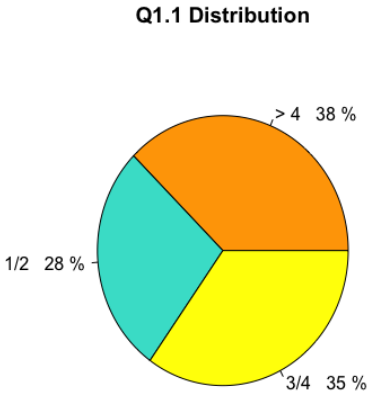
6. Small IT and telecommunication equipment (no external dimension more than 50 cm)

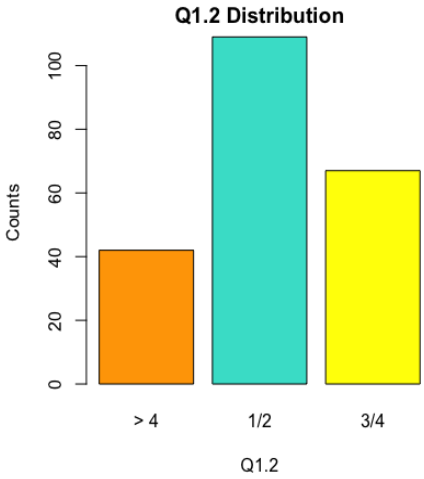
Appendix II: WEEE Label

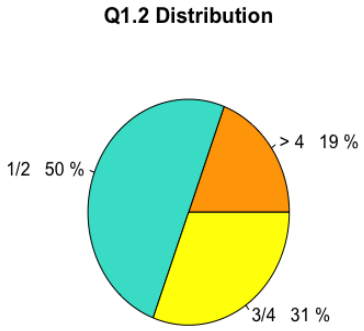
The crossed-out wheeled bin is used as the symbol denoting separate collection for EEE, as shown below. The emblem must be clearly, legibly, and permanently imprinted.

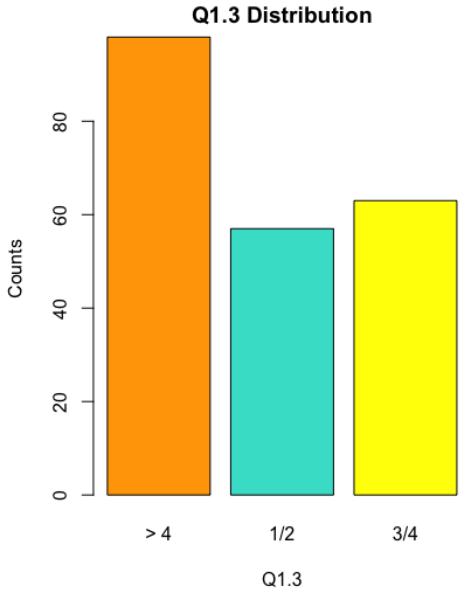
Appendix III: Distribution of Answers

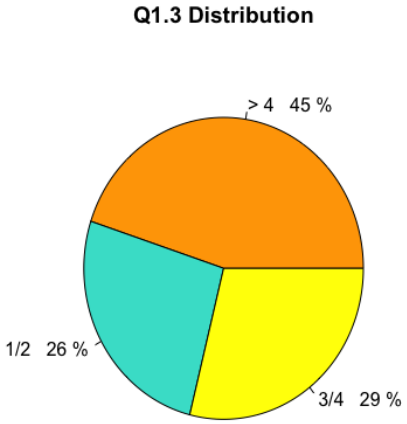


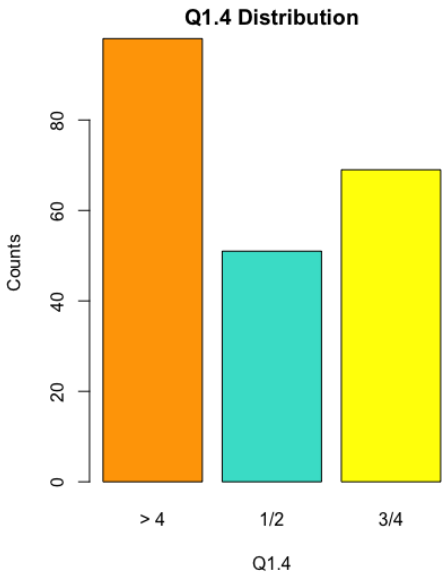


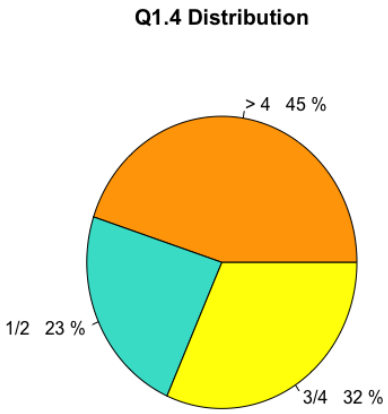


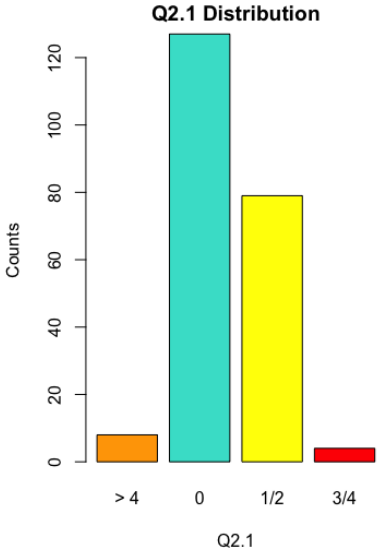


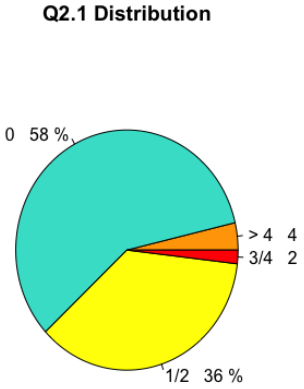


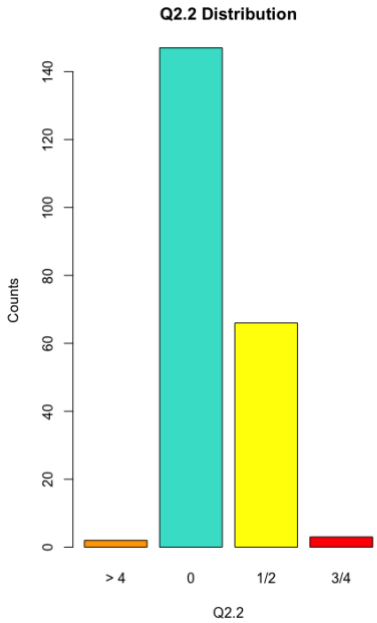


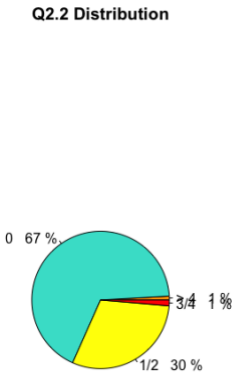

Q1.4 Distribution
Counts
0
20
40
60
80
> 4
1/2
3/4
Q1.4

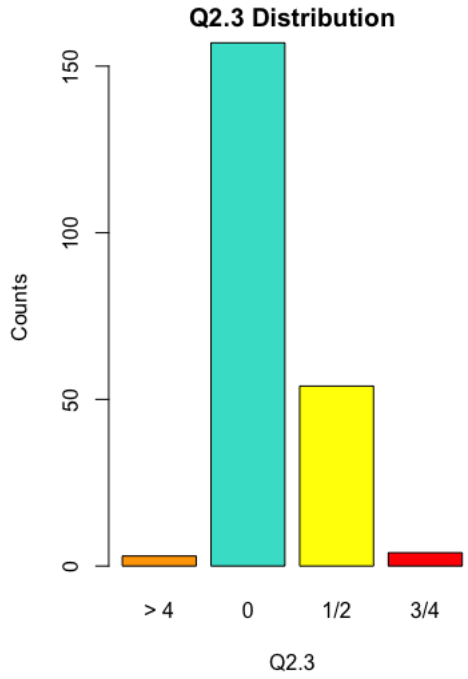

Q1.4 Distribution
> 4 45 %
1/2 23 %
3/4 32 %

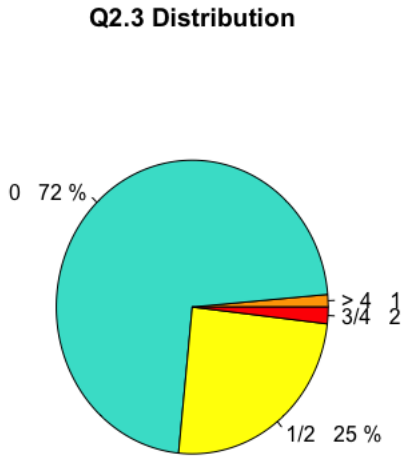

Q2.1 Distribution
Counts
0
20
40
60
80
100
120
> 4
0
1/2
3/4
Q2.1

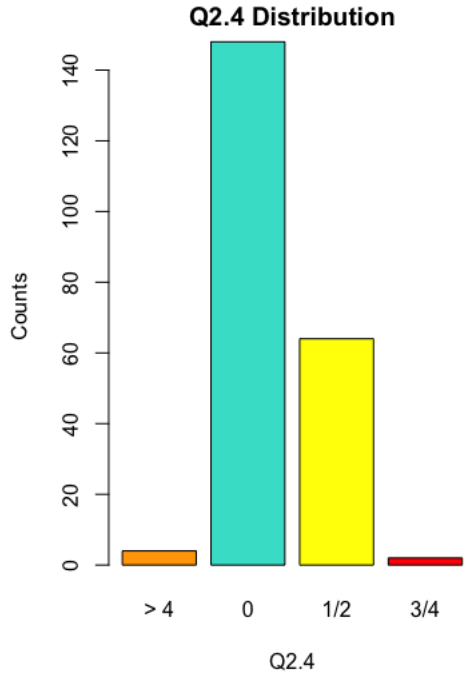

Q2.1 Distribution
0 58 %
> 4 4
3/4 2
1/2 36 %

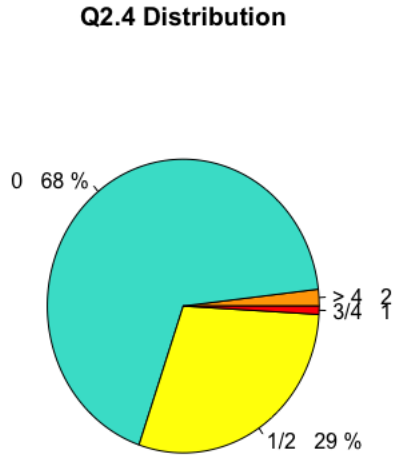

Q2.2 Distribution
Counts
0
20
40
60
80
100
120
140
> 4
0
1/2
3/4
Q2.2

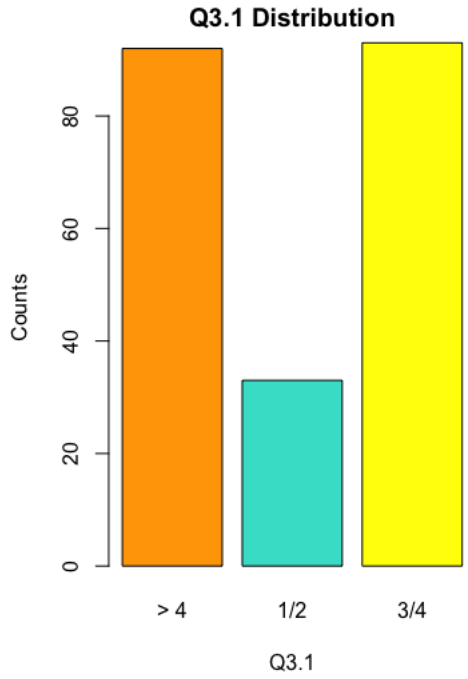

Q2.2 Distribution
0 67 %
1/2 30 %

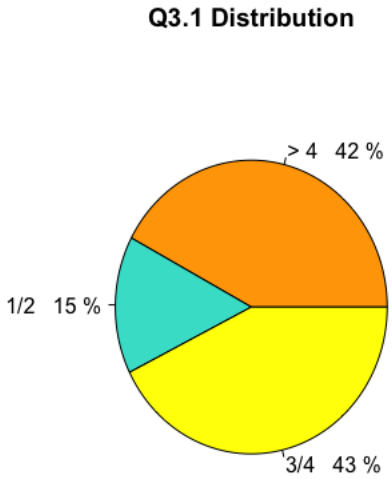

Q2.3 Distribution
Counts
0
50
100
150
> 4
0
1/2
3/4
Q2.3

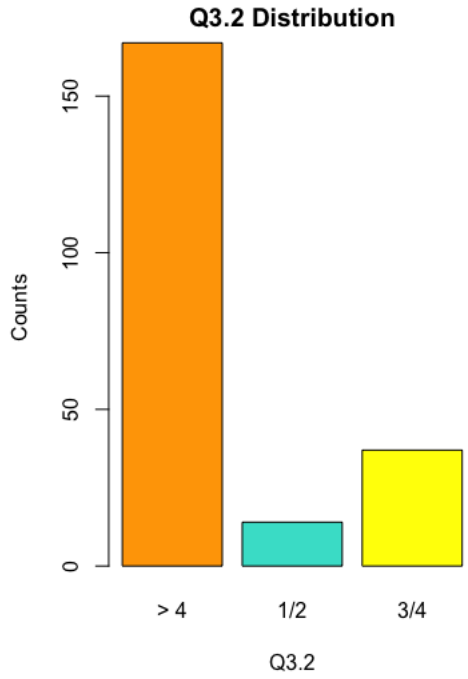

Q2.3 Distribution
0 72 %
> 4 1
3/4 2
1/2 25 %

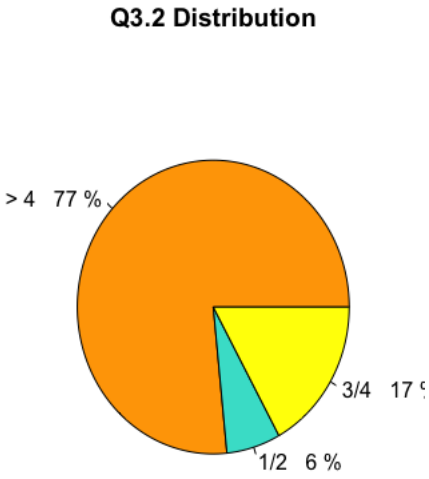

Q2.4 Distribution
Counts
0
20
40
60
80
100
120
140
> 4
0
1/2
3/4
Q2.4

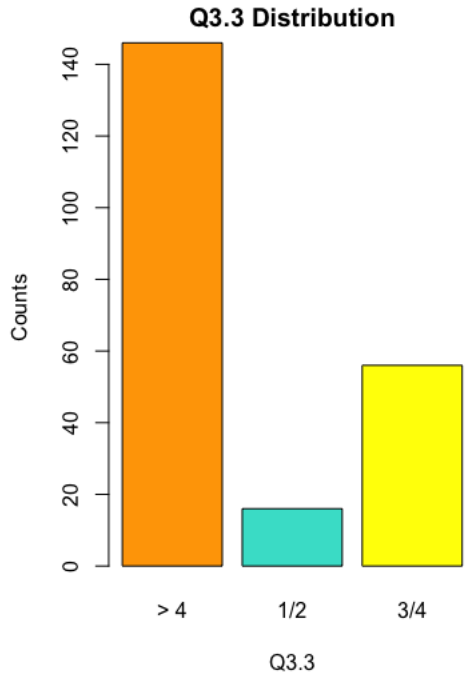

Q2.4 Distribution
0 68 %
> 4 2
3/4 1
1/2 29 %

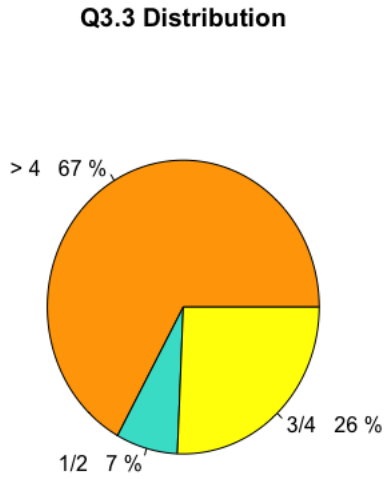

Q3.1 Distribution
Counts
0
20
40
60
80
> 4
1/2
3/4
Q3.1

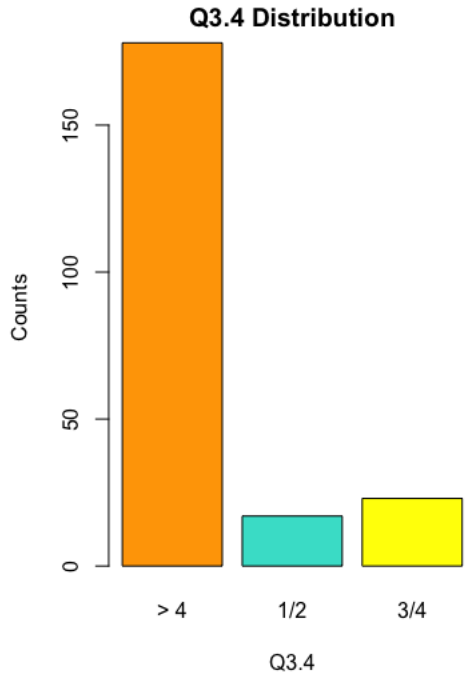

Q3.1 Distribution
> 4 42 %
1/2 15 %
3/4 43 %

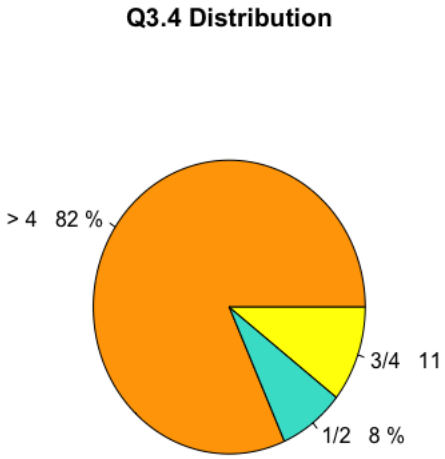

Q3.2 Distribution
Counts
0
50
100
150
> 4
1/2
3/4
Q3.2

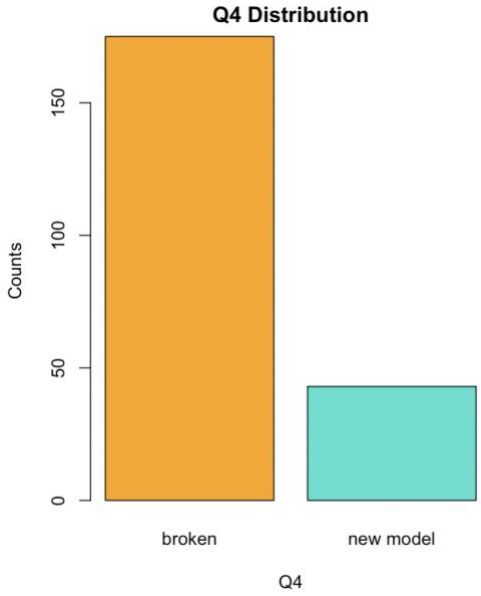

Q3.2 Distribution
> 4 77 %
3/4 17 %
1/2 6 %

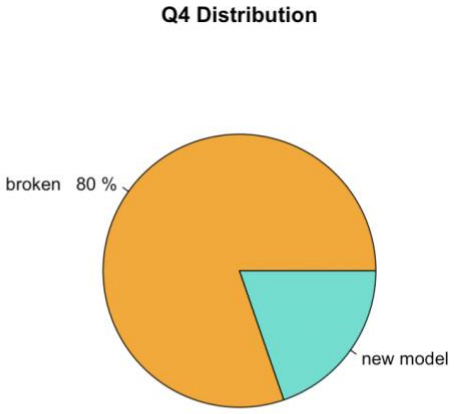

Q3.3 Distribution
Counts
0
20
40
60
80
100
120
140
> 4
1/2
3/4
Q3.3

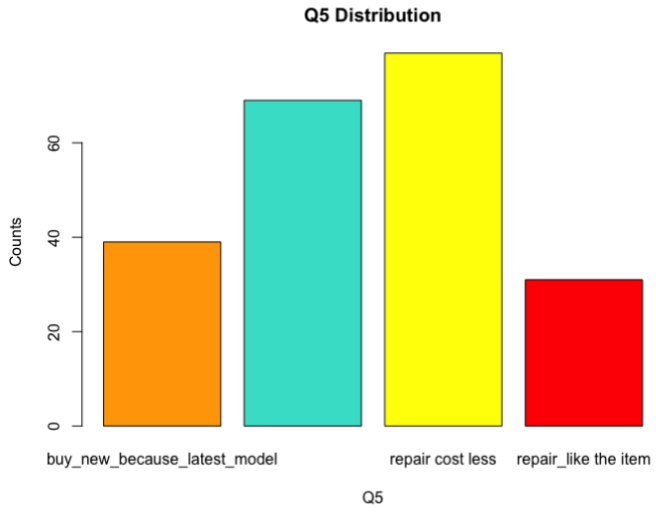

Q3.3 Distribution
> 4 67 %
3/4 26 %
1/2 7 %

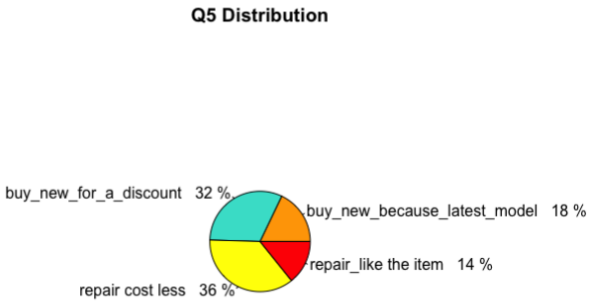

Q3.4 Distribution
Counts
0
50
100
150
> 4
1/2
3/4
Q3.4

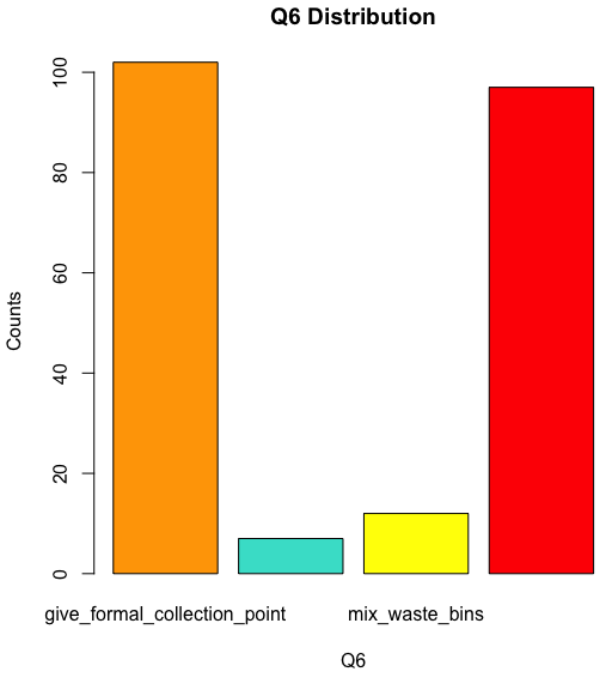

Q3.4 Distribution
> 4 82 %
3/4 11
1/2 8 %

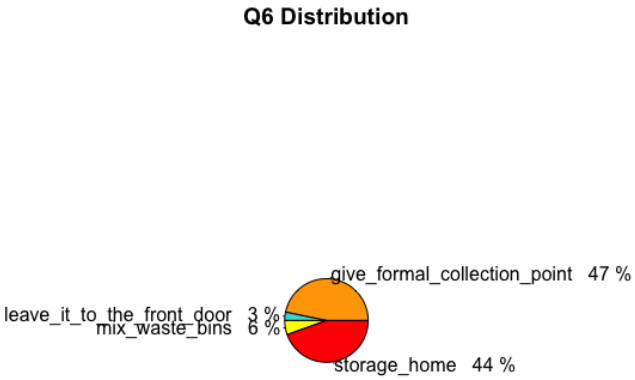

Q4 Distribution
Counts
0
50
100
150
broken
new model
Q4

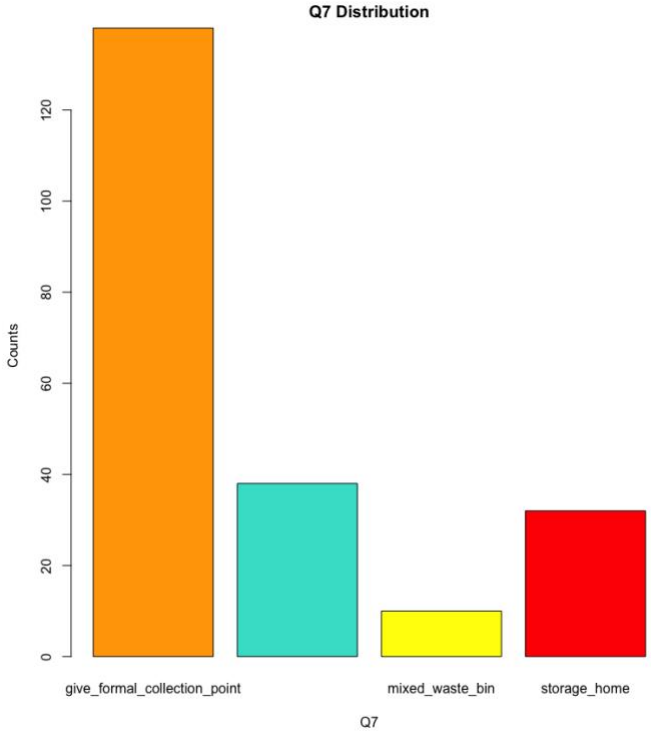

Q4 Distribution
broken 80 %
new model

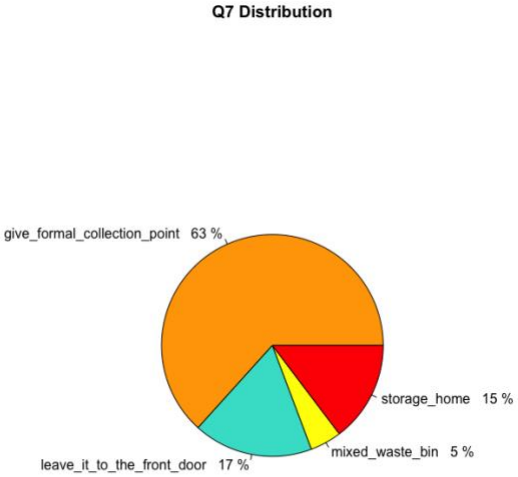

Q5 Distribution
Counts
0
20
40
60
buy_new_because_latest_model
repair cost less
repair_like the item
Q5

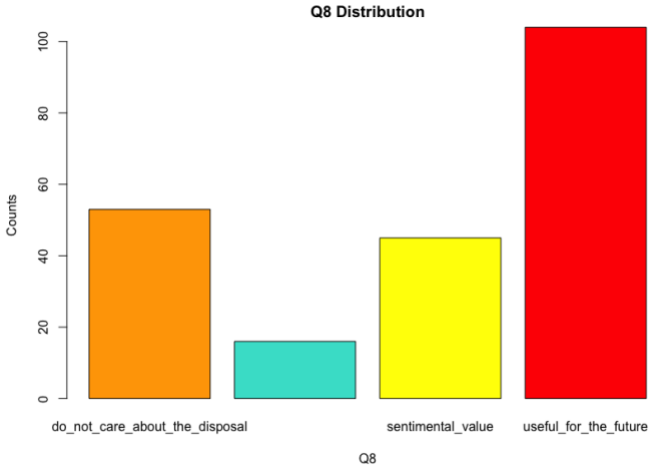

Q5 Distribution
buy_new_for_a_discount 32 %
buy_new_because_latest_model 18 %
repair_like the item 14 %
repair cost less 36 %

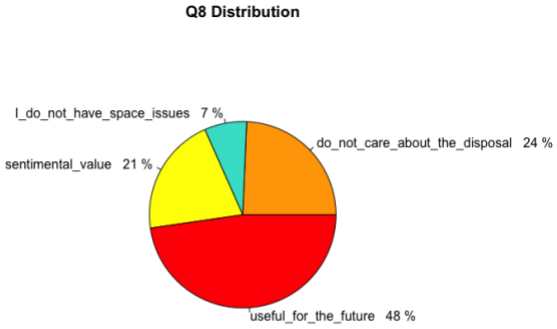

Q6 Distribution
Counts
0
20
40
60
80
100
give_formal_collection_point
mix_waste_bins
Q6

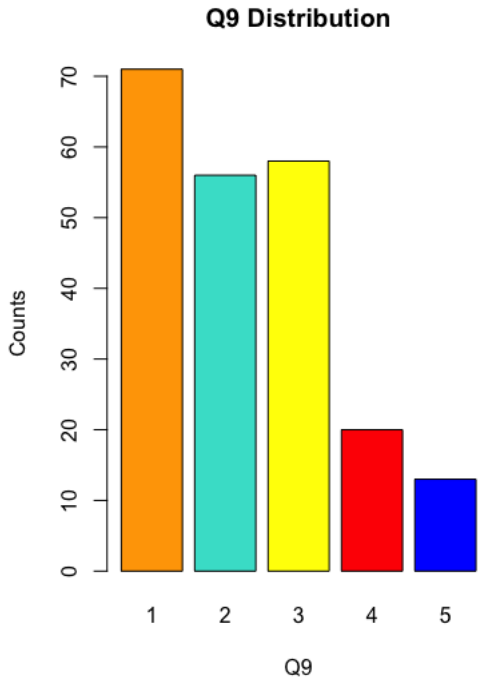

Q6 Distribution
give_formal_collection_point 47 %
leave_it_to_the_front_door 3 %
mix_waste_bins 6 %
storage_home 44 %

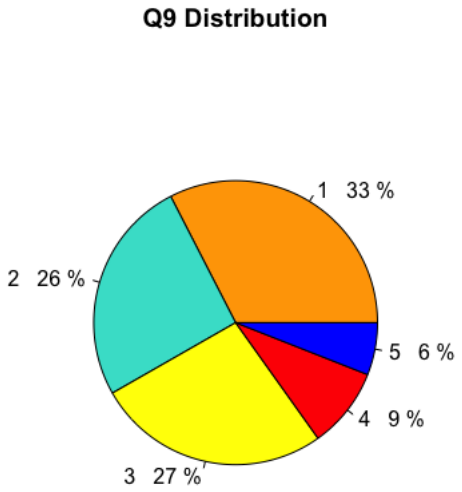

Q7 Distribution
Counts
0
20
40
60
80
100
120
give_formal_collection_point
mixed_waste_bin
storage_home
Q7

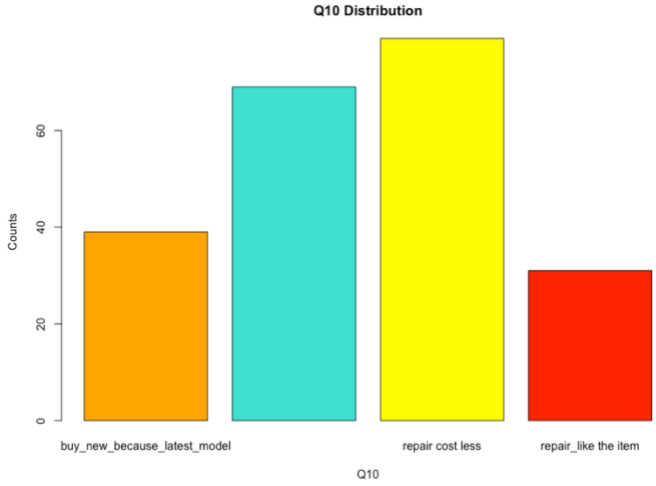

Q7 Distribution
give_formal_collection_point 63 %
storage_home 15 %
mixed_waste_bin 5 %
leave_it_to_the_front_door 17 %

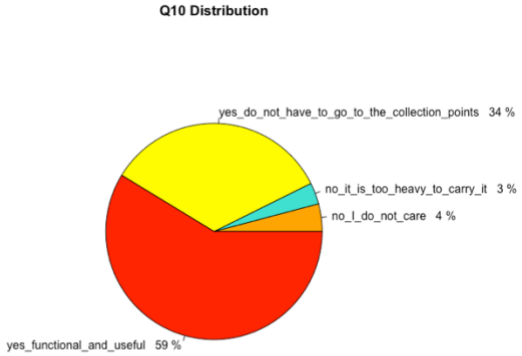

Q8 Distribution
Counts
0
20
40
60
80
100
do_not_care_about_the_disposal
sentimental_value
useful_for_the_future
Q8

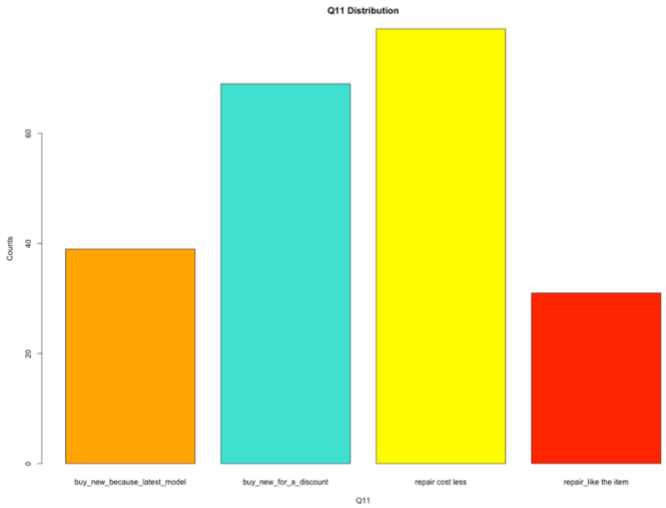

Q8 Distribution
I_do_not_have_space_issues 7 %
do_not_care_about_the_disposal 24 %
sentimental_value 21 %
useful_for_the_future 48 %

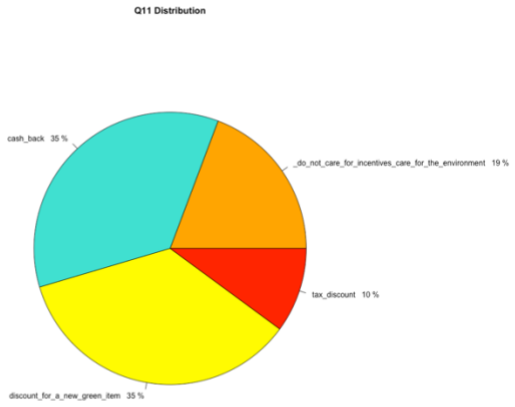

Q9 Distribution
Counts
0
10
20
30
40
50
60
70
1
2
3
4
5
Q9

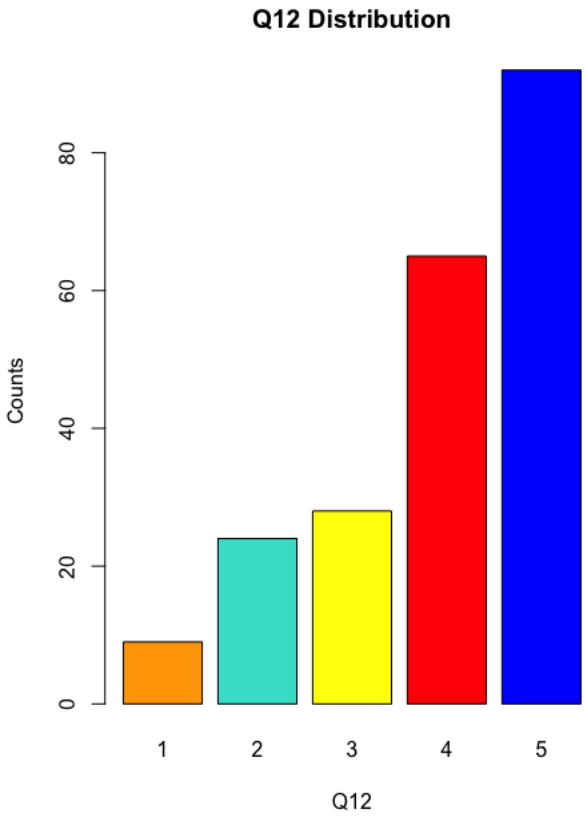

Q9 Distribution
1 33 %
2 26 %
3 27 %
4 9 %
5 6 %

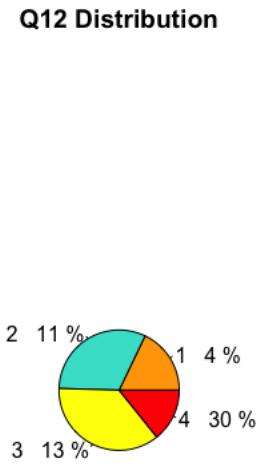

Q10 Distribution
Counts
0
20
40
60
buy_new_because_latest_model
repair cost less
repair_like the item
Q10

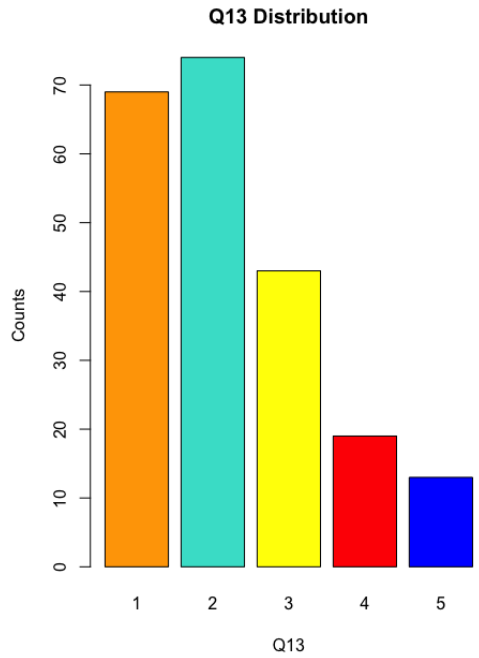

Q10 Distribution
yes_do_not_have_to_go_to_the_collection_points 34 %
no_it_is_too_heavy_to_carry_it 3 %
no_I_do_not_care 4 %
yes_functional_and_useful 59 %

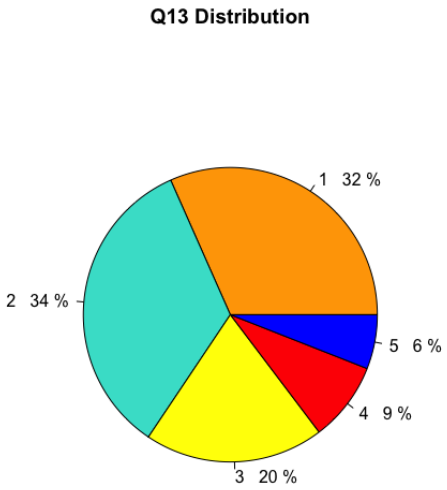

Q11 Distribution
Counts
0
20
40
60
buy_new_because_latest_model
buy_new_for_a_discount
repair cost less
repair_like the item
Q11

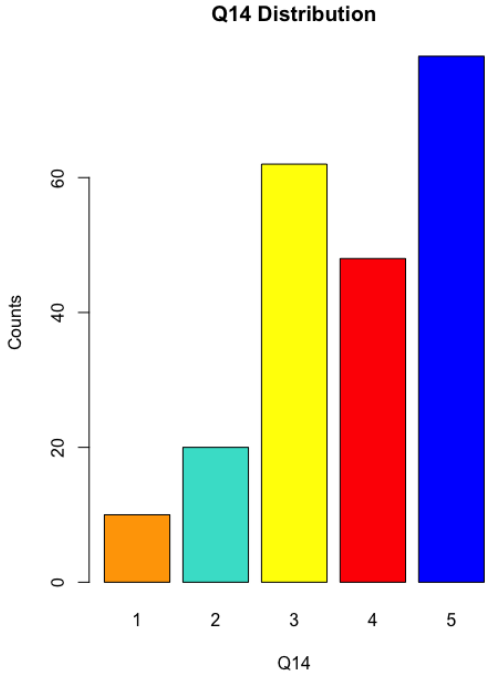

Q11 Distribution
cash_back 35 %
_do_not_care_for_incentives_care_for_the_environment 19 %
tax_discount 10 %
discount_for_a_new_green_item 35 %

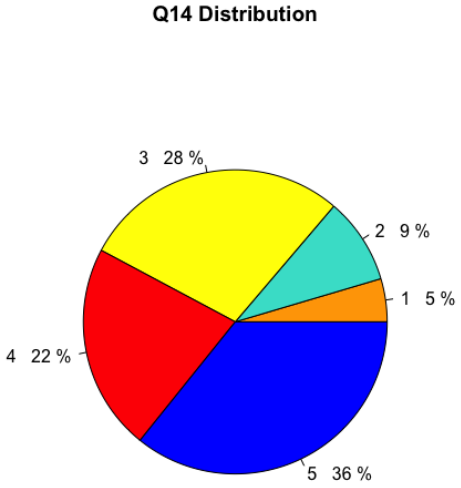

Q12 Distribution
Counts
0
20
40
60
80
1
2
3
4
5
Q12

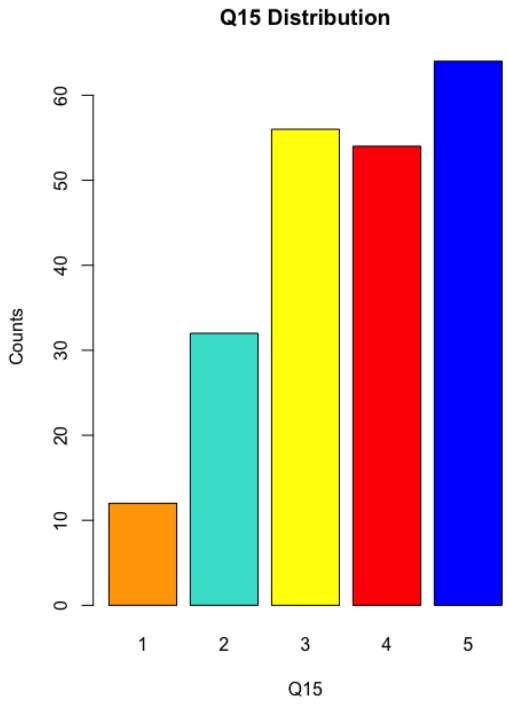

Q12 Distribution
2 11 %
1 4 %
4 30 %
3 13 %

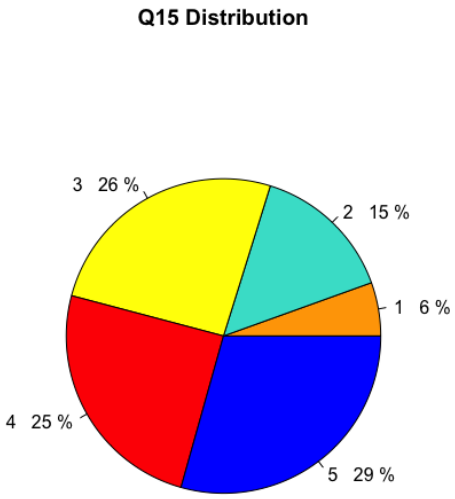

Q13 Distribution
Counts
0
10
20
30
40
50
60
70
1
2
3
4
5
Q13

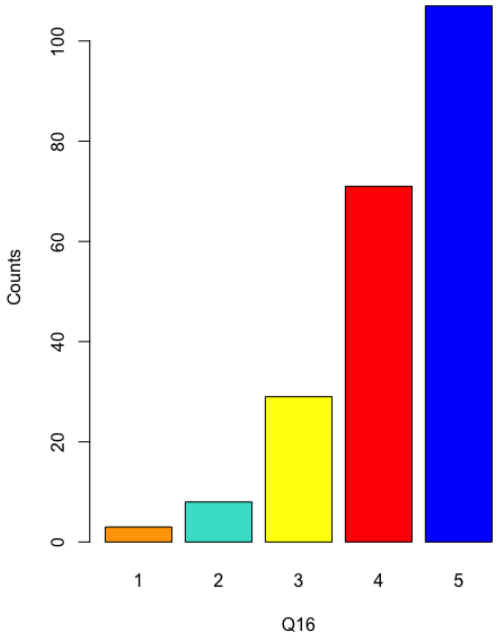

Q13 Distribution
1 32 %
2 34 %
3 20 %
4 9 %
5 6 %

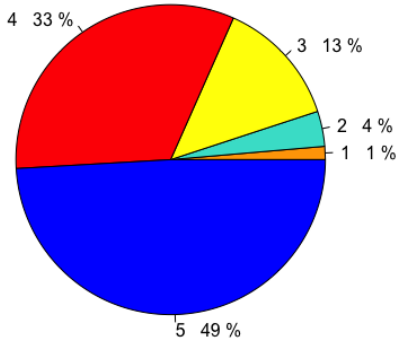

Q14 Distribution
Counts
0
20
40
60
1
2
3
4
5
Q14


Q14 Distribution
3 28 %
2 9 %
1 5 %
4 22 %
5 36 %


Q15 Distribution
Counts
0
10
20
30
40
50
60
1
2
3
4
5
Q15


Q15 Distribution
3 26 %
2 15 %
1 6 %
4 25 %
5 29 %


Q16 Distribution
Counts
0
20
40
60
80
100
1
2
3
4
5
Q16


Q5 Distribution
4 33 %
3 13 %
2 4 %
1 1 %
5 49 %

Appendix IV: Questionnaire

Comportamento dos consumidores face ao consumo, eliminação e reciclagem de equipamentos electrónicos domésticos

Este breve questionário servirá de suporte à minha tese final de mestrado no domínio dos resíduos eletrónicos e da economia circular. O preenchimento do questionário tem uma duração estimada de 2 minutos. Todos os resultados são anónimos. Agradecemos desde já a sua amável cooperação.

Non condiviso

Avanti Pagina 1 di 5 Cancella modulo

Non inviare mai le password tramite Moduli Google.

Aspectos Sociodemográficos

Qual é a sua idade? *

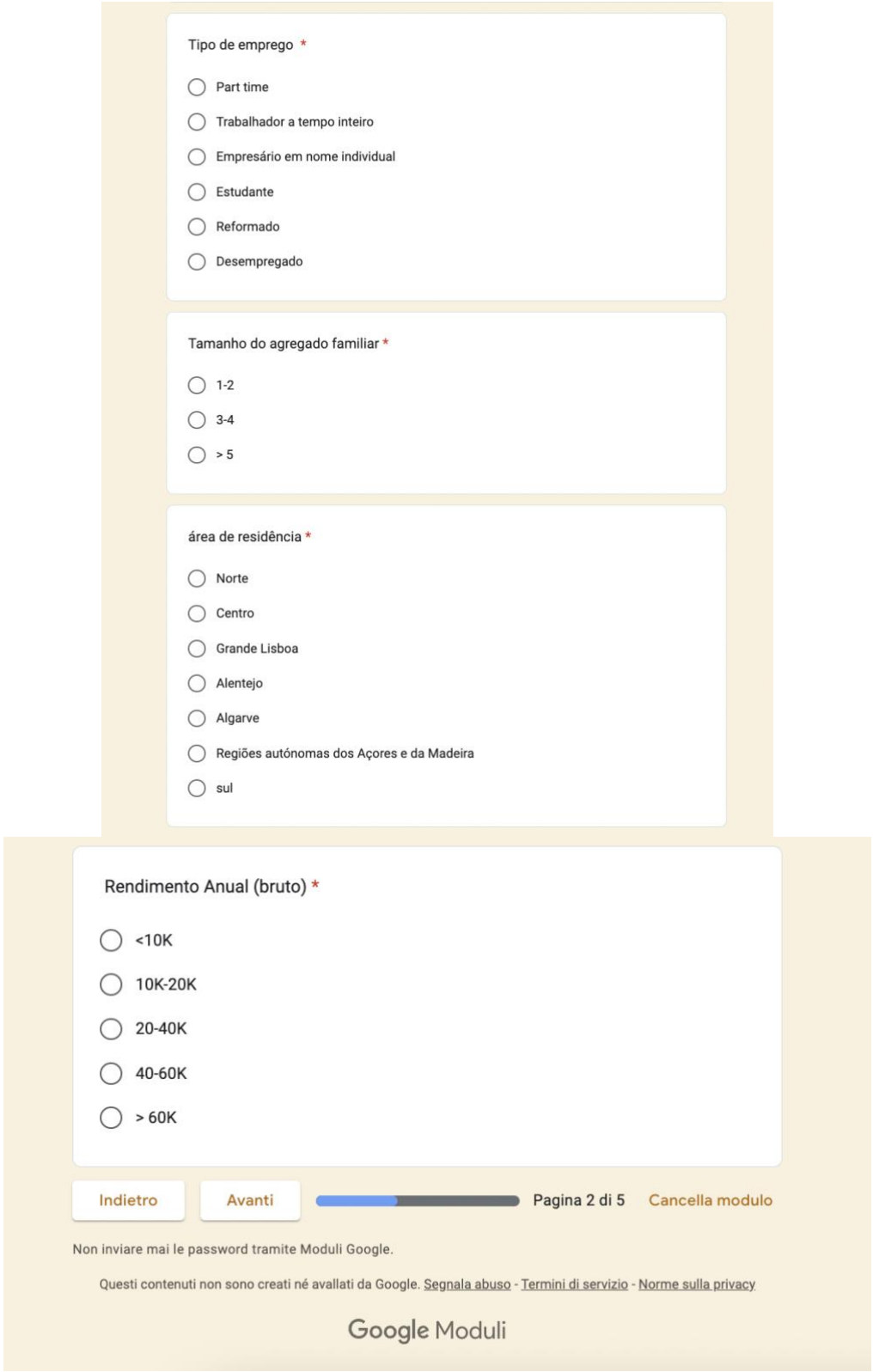
- ◯ <17
- ◯ 17-25
- ◯ 26-35
- ◯ 36-50
- ◯ >50

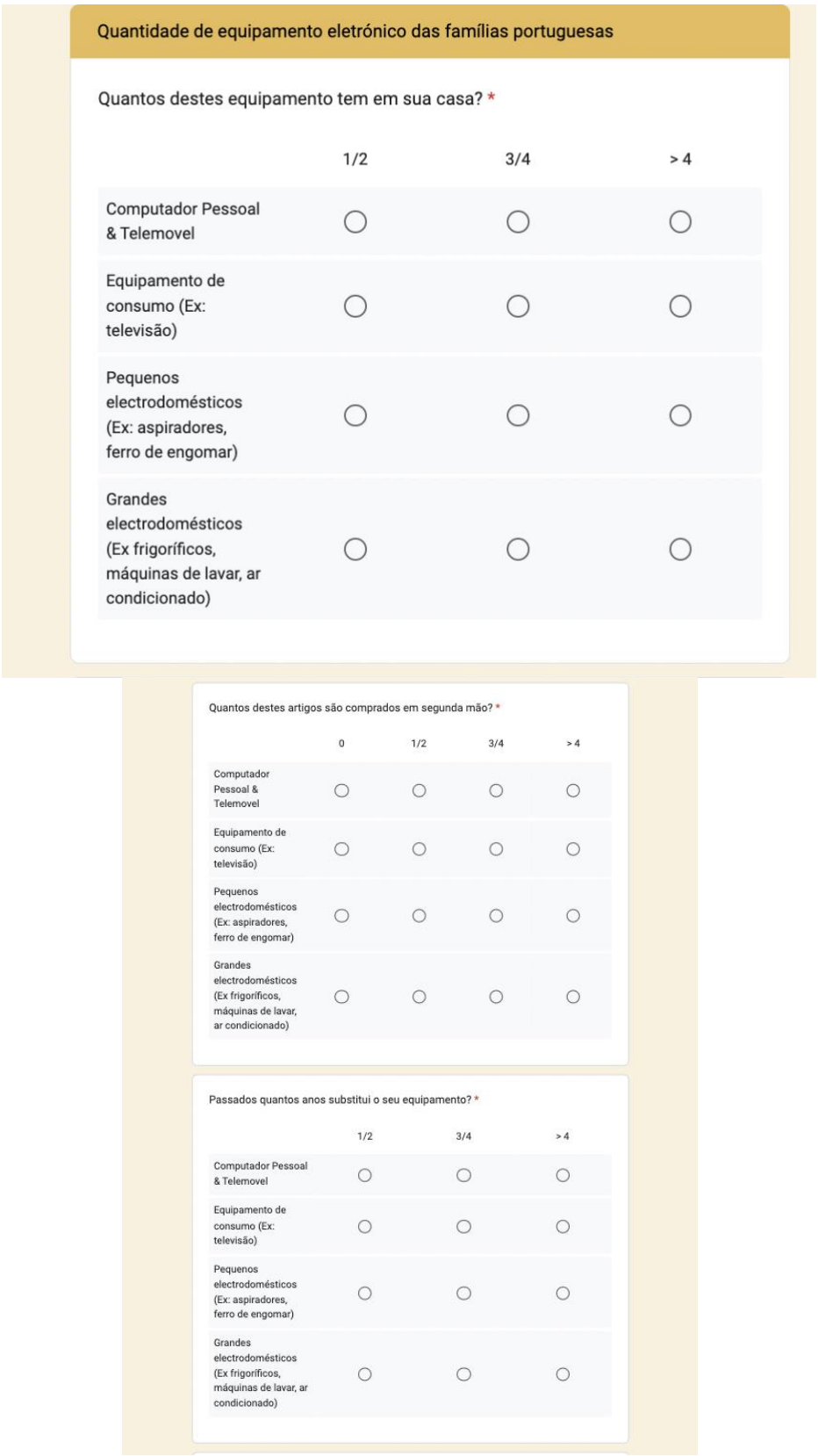
Género: *

- ◯ Feminino
- ◯ Masculino
- ◯ outros

Educação *

- ◯ ensino universitário
- ◯ ensino secundário
- ◯ outros


Tipo de emprego *
Part time
Trabalhador a tempo inteiro
Empresário em nome individual
Estudante
Reformado
Desempregado
Tamanho do agregado familiar *
1-2
3-4
> 5
área de residência *
Norte
Centro
Grande Lisboa
Alentejo
Algarve
Regiões autónomas dos Açores e da Madeira
sul
Rendimento Anual (bruto) *
<10K
10K-20K
20-40K
40-60K
> 60K
Indietro
Avanti
Pagina 2 di 5
Cancella modulo
Non inviare mai le password tramite Moduli Google.
Questi contenuti non sono creati né avallati da Google. Segnala abuso - Termini di servizio - Norme sulla privacy
Google Moduli



Quantidade de equipamento eletrónico das famílias portuguesas

Quantos destes equipamento tem em sua casa? *

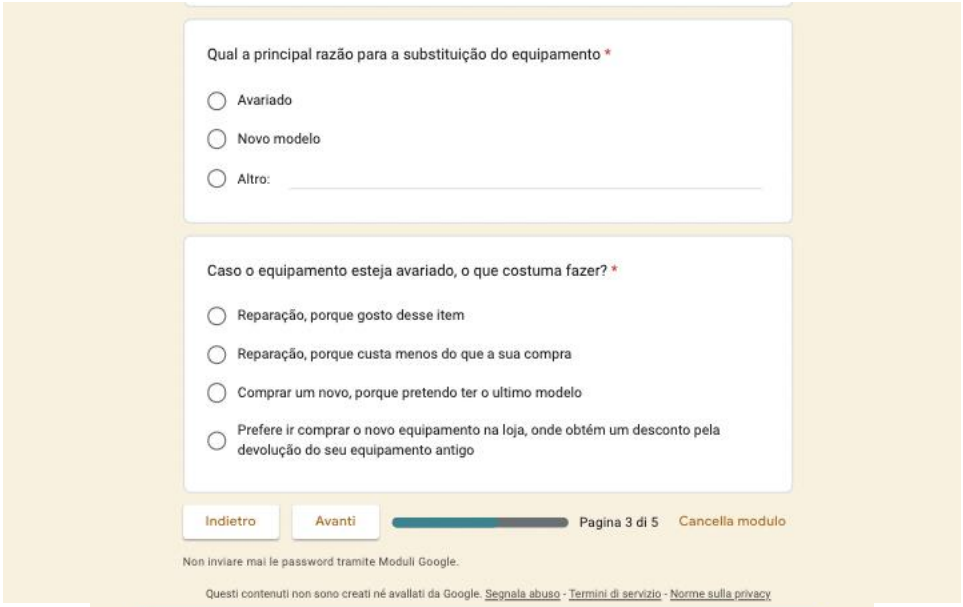
	1/2	3/4	> 4
Computador Pessoal & Telemovel	○	○	○
Equipamento de consumo (Ex: televisão)	○	○	○
Pequenos electrodomésticos (Ex: aspiradores, ferro de engomar)	○	○	○
Grandes electrodomésticos (Ex frigoríficos, máquinas de lavar, ar condicionado)	○	○	○

Quantos destes artigos são comprados em segunda mão? *

	0	1/2	3/4	> 4
Computador Pessoal & Telemovel	○	○	○	○
Equipamento de consumo (Ex: televisão)	○	○	○	○
Pequenos electrodomésticos (Ex: aspiradores, ferro de engomar)	○	○	○	○
Grandes electrodomésticos (Ex frigoríficos, máquinas de lavar, ar condicionado)	○	○	○	○

Passados quantos anos substitui o seu equipamento? *

	1/2	3/4	> 4
Computador Pessoal & Telemovel	○	○	○
Equipamento de consumo (Ex: televisão)	○	○	○
Pequenos electrodomésticos (Ex: aspiradores, ferro de engomar)	○	○	○
Grandes electrodomésticos (Ex frigoríficos, máquinas de lavar, ar condicionado)	○	○	○



Qual a principal razão para a substituição do equipamento *

- ◯ Avariado
- ◯ Novo modelo
- ◯ Altro: _____

Caso o equipamento esteja avariado, o que costuma fazer? *

- ◯ Reparação, porque gosto desse item
- ◯ Reparação, porque custa menos do que a sua compra
- ◯ Comprar um novo, porque pretendo ter o ultimo modelo
- ◯ Prefere ir comprar o novo equipamento na loja, onde obtém um desconto pela devolução do seu equipamento antigo

Indietro Avanti Pagina 3 di 5 Cancella modulo

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Comportamento dos consumidores relativamente à eliminação dos equipamentos eléctricos domésticos

O que faz aos pequenos electrodomésticos que deixa de usar? *

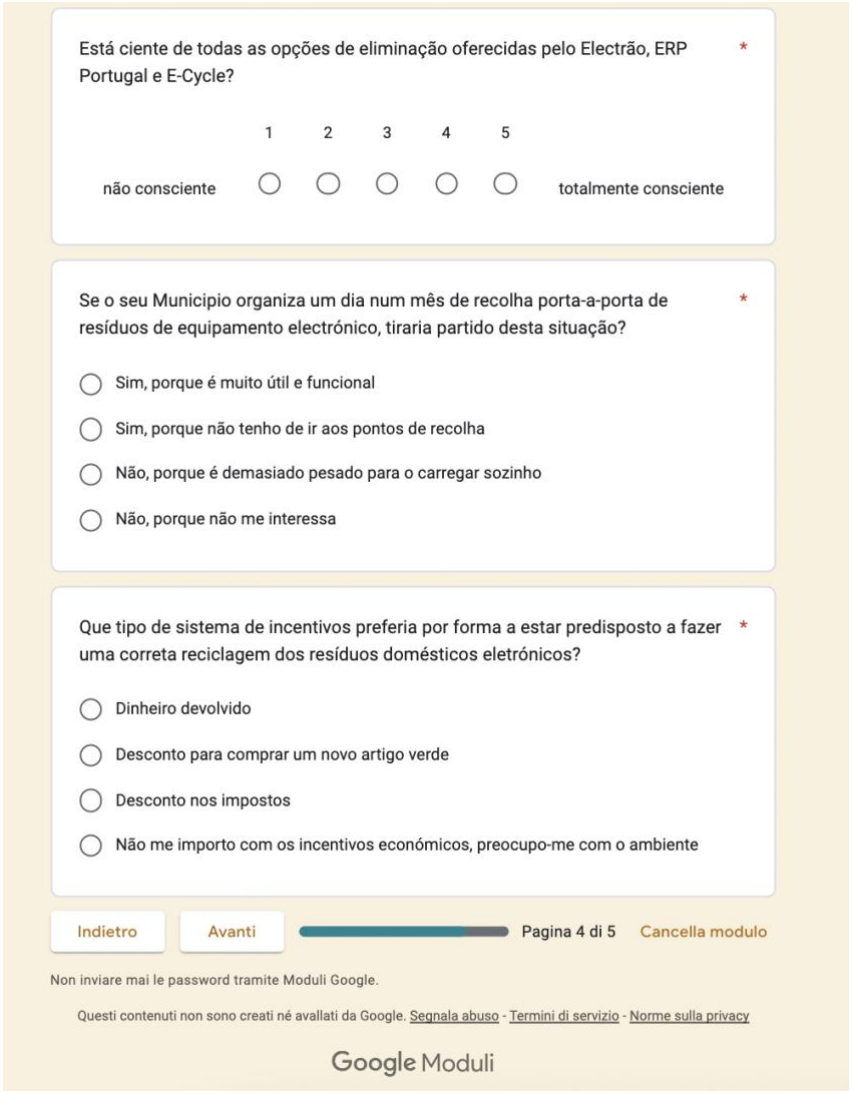
- ◯ Armazenamento em casa
- ◯ Entrega num ponto autorizado de recolha
- ◯ Coloco à porta de casa
- ◯ Coloco no contentor dos resíduos indiferenciados

O que faz aos grandes electrodomésticos que deixa de usar? *

- ◯ Armazenamento em casa
- ◯ Entrega num ponto autorizado de recolha
- ◯ Coloco à porta de casa
- ◯ Coloco no contentor dos residuos indefernciados

Quais poderiam ser as possíveis razões para armazenar/manter os seus artigos? *

- ◯ Pode ser útil para o futuro
- ◯ tem valor sentimental
- ◯ Posso guardá-lo, uma vez que não tenho problemas de espaço
- ◯ Não me apetece ter trabalho com isso



Está ciente de todas as opções de eliminação oferecidas pelo Electrão, ERP Portugal e E-Cycle? *

	1	2	3	4	5	
não consciente	◯	◯	◯	◯	◯	totalmente consciente

Se o seu Municipio organiza um dia num mês de recolha porta-a-porta de resíduos de equipamento electrónico, tiraria partido desta situação? *

- ◯ Sim, porque é muito útil e funcional
- ◯ Sim, porque não tenho de ir aos pontos de recolha
- ◯ Não, porque é demasiado pesado para o carregar sozinho
- ◯ Não, porque não me interessa

Que tipo de sistema de incentivos preferia por forma a estar predisposto a fazer uma correta reciclagem dos resíduos domésticos eletrónicos? *

- ◯ Dinheiro devolvido
- ◯ Desconto para comprar um novo artigo verde
- ◯ Desconto nos impostos
- ◯ Não me importo com os incentivos económicos, preocupo-me com o ambiente

Indietro Avanti Pagina 4 di 5 Cancella modulo

Non inviare mai le password tramite Moduli Google.

Questi contenuti non sono creati né avallati da Google. Segnala abuso - Termini di servizio - Norme sulla privacy

Google Moduli

Importância da reciclagem do lixo electrónico doméstico

Sabia que dentro do lixo electrónico doméstico existem materiais tóxicos? *

	1	2	3	4	5	
não consciente	○	○	○	○	○	plenamente consciente

Está a par da legislação europeia e portuguesa que abrange o lixo electrónico doméstico? *

	1	2	3	4	5	
não consciente	○	○	○	○	○	plenamente consciente

Está ciente de que ao reciclar correctamente o resíduos electrónicos domésticos pode promover a circularidade de alguns materiais, isto é, poderem ser utilizados em novos produtos? *

	1	2	3	4	5	
não consciente	○	○	○	○	○	plenamente consciente

Está ciente dos efeitos ao atirar o lixo electrónico doméstico para o caixote de lixo de resíduos mistos? *

	1	2	3	4	5	
não consciente	○	○	○	○	○	plenamente consciente

Para si, qual a importância de reciclar o lixo eletrónico doméstico *

	1	2	3	4	5	
Nada importante	○	○	○	○	○	Muito importante

Indietro Invia Pagina 5 di 5 Cancella modulo

Appendix V: R-Code

```
require(GGally)
require(mdscore)
rm(list=ls())

setwd("/Users/giuliamolinari/Desktop/R- studio")
library (readxl)
# Caricamento del dataset
Dataset_0 = read_xlsx("/Users/giuliamolinari/Desktop/R- studio/Dataset.xlsx")

Dataset = Dataset_0[,-1]
class(Dataset)
summary(Dataset)
table(summary(Dataset))
#library (dplyr)
#glimpse(Dataset)
str(Dataset)

dim (Dataset)
sum (is.na (Dataset))

library(Amelia)
missmap(Dataset, col = c ("blue", "red"), legend = FALSE)

library (psych)
describe (Dataset)
summary (Dataset)

Dataset_new = Dataset
Dataset_new$AGE = as.factor(Dataset_new$AGE)
Dataset_new$SEX = as.factor(Dataset_new$SEX)
Dataset_new$EDUCATION = as.factor(Dataset_new$EDUCATION)
Dataset_new$EMPLOYMENT = as.factor(Dataset_new$EMPLOYMENT)
Dataset_new$FAMILYSIZE = as.factor(Dataset_new$FAMILYSIZE)
Dataset_new$RESIDENCY = as.factor(Dataset_new$RESIDENCY)
Dataset_new$INCOME = as.factor(Dataset_new$INCOME)
Dataset_new$Q1.1 = as.factor(Dataset_new$Q1.1)
Dataset_new$Q1.2 = as.factor(Dataset_new$Q1.2)
Dataset_new$Q1.3 = as.factor(Dataset_new$Q1.3)
Dataset_new$Q1.4 = as.factor(Dataset_new$Q1.4)
Dataset_new$Q2.1 = as.factor(Dataset_new$Q2.1)
Dataset_new$Q2.2 = as.factor(Dataset_new$Q2.2)
Dataset_new$Q2.3 = as.factor(Dataset_new$Q2.3)
Dataset_new$Q2.4 = as.factor(Dataset_new$Q2.4)
Dataset_new$Q3.1 = as.factor(Dataset_new$Q3.1)
Dataset_new$Q3.2 = as.factor(Dataset_new$Q3.2)
Dataset_new$Q3.3 = as.factor(Dataset_new$Q3.3)
Dataset_new$Q3.4 = as.factor(Dataset_new$Q3.4)
Dataset_new$Q4 = as.factor(Dataset_new$Q4)
Dataset_new$Q5 = as.factor(Dataset_new$Q5)
Dataset_new$Q6 = as.factor(Dataset_new$Q6)
Dataset_new$Q7 = as.factor(Dataset_new$Q7)
Dataset_new$Q8 = as.factor(Dataset_new$Q8)
Dataset_new$Q9 = as.factor(Dataset_new$Q9)
Dataset_new$Q10 = as.factor(Dataset_new$Q10)
Dataset_new$Q11 = as.factor(Dataset_new$Q11)
Dataset_new$Q12 = as.factor(Dataset_new$Q12)
Dataset_new$Q13 = as.factor(Dataset_new$Q13)
Dataset_new$Q14 = as.factor(Dataset_new$Q14)
Dataset_new$Q15 = as.factor(Dataset_new$Q15)
Dataset_new$Q16 = as.factor(Dataset_new$Q16)
```

```
summary(Dataset_new)

Q1.1= chisq.test (table (Dataset_new$Q1.1, Dataset_new$SEX), correct = FALSE)
Q1.1$statistic # chiquadro
Q1.1$p.value  # pvalue

Q1.2= chisq.test (table (Dataset_new$Q1.2, Dataset_new$SEX), correct = FALSE)
Q1.2$statistic # chiquadro
Q1.2$p.value  # pvalue

Q1.3= chisq.test (table (Dataset_new$Q1.3, Dataset_new$SEX), correct = FALSE)
Q1.3$statistic # chiquadro
Q1.3$p.value  # pvalue

Q1.4= chisq.test (table (Dataset_new$Q1.4, Dataset_new$SEX), correct = FALSE)
Q1.4$statistic # chiquadro
Q1.4$p.value  # pvalue

Q1.1= chisq.test (table (Dataset_new$Q1.1, Dataset_new$AGE), correct = FALSE)
Q1.1$statistic # chiquadro
Q1.1$p.value  # pvalue

Q1.2= chisq.test (table (Dataset_new$Q1.2, Dataset_new$AGE), correct = FALSE)
Q1.2$statistic # chiquadro
Q1.2$p.value  # pvalue

Q1.3= chisq.test (table (Dataset_new$Q1.3, Dataset_new$AGE), correct = FALSE)
Q1.3$statistic # chiquadro
Q1.3$p.value  # pvalue

Q1.4= chisq.test (table (Dataset_new$Q1.4, Dataset_new$AGE), correct = FALSE)
Q1.4$statistic # chiquadro
Q1.4$p.value  # pvalue

Q1.1= chisq.test (table (Dataset_new$Q1.1, Dataset_new$EMPLOYMENT), correct = FALSE)
Q1.1$statistic # chiquadro
Q1.1$p.value  # pvalue

Q1.2= chisq.test (table (Dataset_new$Q1.2, Dataset_new$EMPLOYMENT), correct = FALSE)
# Observazione - Il test chi-square mostra che EMPLOYMENT e N_PC_CELLPHONE non sono associate
Q1.2$statistic # chiquadro
Q1.2$p.value  # pvalue

Q1.3= chisq.test (table (Dataset_new$Q1.3, Dataset_new$EMPLOYMENT), correct = FALSE)
Q1.3$statistic # chiquadro
Q1.3$p.value  # pvalue

Q1.4= chisq.test (table (Dataset_new$Q1.4, Dataset_new$EMPLOYMENT), correct = FALSE)
Q1.4$statistic # chiquadro
Q1.4$p.value  # pvalue

Q1.1= chisq.test (table (Dataset_new$Q1.1, Dataset_new$EDUCATION), correct = FALSE)
Q1.1$statistic # chiquadro
Q1.1$p.value  # pvalue

Q1.2= chisq.test (table (Dataset_new$Q1.2, Dataset_new$EDUCATION), correct = FALSE)
Q1.2$statistic # chiquadro
Q1.2$p.value  # pvalue

Q1.3= chisq.test (table (Dataset_new$Q1.3, Dataset_new$EDUCATION), correct = FALSE)
Q1.3$statistic # chiquadro
Q1.3$p.value  # pvalue

Q1.4= chisq.test (table (Dataset_new$Q1.4, Dataset_new$EDUCATION), correct = FALSE)
Q1.4$statistic # chiquadro
```

```
Q1.4$p.value  # pvalue

Q1.1= chisq.test (table (Dataset_new$Q1.1, Dataset_new$FAMILYSIZE), correct = FALSE)
Q1.1$statistic # chiquadro
Q1.1$p.value  # pvalue

Q1.2= chisq.test (table (Dataset_new$Q1.2, Dataset_new$FAMILYSIZE), correct = FALSE)
Q1.2$statistic # chiquadro
Q1.2$p.value  # pvalue

Q1.3= chisq.test (table (Dataset_new$Q1.3, Dataset_new$FAMILYSIZE), correct = FALSE)
Q1.3$statistic # chiquadro
Q1.3$p.value  # pvalue

Q1.4= chisq.test (table (Dataset_new$Q1.4, Dataset_new$FAMILYSIZE), correct = FALSE)
Q1.4$statistic # chiquadro
Q1.4$p.value  # pvalue

Q1.1= chisq.test (table (Dataset_new$Q1.1, Dataset_new$RESIDENCY), correct = FALSE)
Q1.1$statistic # chiquadro
Q1.1$p.value  # pvalue

Q1.2= chisq.test (table (Dataset_new$Q1.2, Dataset_new$RESIDENCY), correct = FALSE)
Q1.2$statistic # chiquadro
Q1.2$p.value  # pvalue

Q1.3= chisq.test (table (Dataset_new$Q1.3, Dataset_new$RESIDENCY), correct = FALSE)
Q1.3$statistic # chiquadro
Q1.3$p.value  # pvalue

Q1.4= chisq.test (table (Dataset_new$Q1.4, Dataset_new$RESIDENCY), correct = FALSE)
Q1.4$statistic # chiquadro
Q1.4$p.value  # pvalue

Q1.1= chisq.test (table (Dataset_new$Q1.1, Dataset_new$INCOME), correct = FALSE)
Q1.1$statistic # chiquadro
Q1.1$p.value  # pvalue

Q1.2= chisq.test (table (Dataset_new$Q1.2, Dataset_new$INCOME), correct = FALSE)
Q1.2$statistic # chiquadro
Q1.2$p.value  # pvalue

Q1.3= chisq.test (table (Dataset_new$Q1.3, Dataset_new$INCOME), correct = FALSE)
Q1.3$statistic # chiquadro
Q1.3$p.value  # pvalue

Q1.4= chisq.test (table (Dataset_new$Q1.4, Dataset_new$INCOME), correct = FALSE)
Q1.4$statistic # chiquadro
Q1.4$p.value  # pvalue

Q2.1= chisq.test (table (Dataset_new$Q2.1, Dataset_new$SEX), correct = FALSE)
Q2.1$statistic # chiquadro
Q2.1$p.value  # pvalue

Q2.2= chisq.test (table (Dataset_new$Q2.2, Dataset_new$SEX), correct = FALSE)
Q2.2$statistic # chiquadro
Q2.2$p.value  # pvalue

Q2.3= chisq.test (table (Dataset_new$Q2.3, Dataset_new$SEX), correct = FALSE)
Q2.3$statistic # chiquadro
Q2.3$p.value  # pvalue

Q2.4= chisq.test (table (Dataset_new$Q2.4, Dataset_new$SEX), correct = FALSE)
Q2.4$statistic # chiquadro
Q2.4$p.value  # pvalue
```

```
Q2.1= chisq.test (table (Dataset_new$Q2.1, Dataset_new$AGE), correct = FALSE)
Q2.1$statistic # chiquadro
Q2.1$p.value  # pvalue

Q2.2= chisq.test (table (Dataset_new$Q2.2, Dataset_new$AGE), correct = FALSE)
Q2.2$statistic # chiquadro
Q2.2$p.value  # pvalue

Q2.3= chisq.test (table (Dataset_new$Q2.3, Dataset_new$AGE), correct = FALSE)
Q2.3$statistic # chiquadro
Q2.3$p.value  # pvalue

Q2.4= chisq.test (table (Dataset_new$Q2.4, Dataset_new$AGE), correct = FALSE)
Q2.4$statistic # chiquadro
Q2.4$p.value  # pvalue

Q2.1= chisq.test (table (Dataset_new$Q2.1, Dataset_new$EDUCATION), correct = FALSE)
Q2.1$statistic # chiquadro
Q2.1$p.value  # pvalue

Q2.2= chisq.test (table (Dataset_new$Q2.2, Dataset_new$EDUCATION), correct = FALSE)
Q2.2$statistic # chiquadro
Q2.2$p.value  # pvalue

Q2.3= chisq.test (table (Dataset_new$Q2.3, Dataset_new$EDUCATION), correct = FALSE)
Q2.3$statistic # chiquadro
Q2.3$p.value  # pvalue

Q2.4= chisq.test (table (Dataset_new$Q2.4, Dataset_new$EDUCATION), correct = FALSE)
Q2.4$statistic # chiquadro
Q2.4$p.value  # pvalue

Q2.1= chisq.test (table (Dataset_new$Q2.1, Dataset_new$EMPLOYMENT), correct = FALSE)
Q2.1$statistic # chiquadro
Q2.1$p.value  # pvalue

Q2.2= chisq.test (table (Dataset_new$Q2.2, Dataset_new$EMPLOYMENT), correct = FALSE)
Q2.2$statistic # chiquadro
Q2.2$p.value  # pvalue

Q2.3= chisq.test (table (Dataset_new$Q2.3, Dataset_new$EMPLOYMENT), correct = FALSE)
Q2.3$statistic # chiquadro
Q2.3$p.value  # pvalue

Q2.4= chisq.test (table (Dataset_new$Q2.4, Dataset_new$EMPLOYMENT), correct = FALSE)
Q2.4$statistic # chiquadro
Q2.4$p.value  # pvalue



Q2.1= chisq.test (table (Dataset_new$Q2.1, Dataset_new$FAMILYSIZE), correct = FALSE)
Q2.1$statistic # chiquadro
Q2.1$p.value  # pvalue

Q2.2= chisq.test (table (Dataset_new$Q2.2, Dataset_new$FAMILYSIZE), correct = FALSE)
Q2.2$statistic # chiquadro
Q2.2$p.value  # pvalue

Q2.3= chisq.test (table (Dataset_new$Q2.3, Dataset_new$FAMILYSIZE), correct = FALSE)
Q2.3$statistic # chiquadro
Q2.3$p.value  # pvalue

Q2.4= chisq.test (table (Dataset_new$Q2.4, Dataset_new$FAMILYSIZE), correct = FALSE)
Q2.4$statistic # chiquadro
```

```
Q2.4$p.value  # pvalue

Q2.1= chisq.test (table (Dataset_new$Q2.1, Dataset_new$RESIDENCY), correct = FALSE)
Q2.1$statistic # chiquadro
Q2.1$p.value  # pvalue

Q2.2= chisq.test (table (Dataset_new$Q2.2, Dataset_new$RESIDENCY), correct = FALSE)
Q2.2$statistic # chiquadro
Q2.2$p.value  # pvalue

Q2.3= chisq.test (table (Dataset_new$Q2.3, Dataset_new$RESIDENCY), correct = FALSE)
Q2.3$statistic # chiquadro
Q2.3$p.value  # pvalue

Q2.4= chisq.test (table (Dataset_new$Q2.4, Dataset_new$RESIDENCY), correct = FALSE)
Q2.4$statistic # chiquadro
Q2.4$p.value  # pvalue

Q2.1= chisq.test (table (Dataset_new$Q2.1, Dataset_new$INCOME), correct = FALSE)
Q2.1$statistic # chiquadro
Q2.1$p.value  # pvalue

Q2.2= chisq.test (table (Dataset_new$Q2.2, Dataset_new$INCOME), correct = FALSE)
Q2.2$statistic # chiquadro
Q2.2$p.value  # pvalue

Q2.3= chisq.test (table (Dataset_new$Q2.3, Dataset_new$INCOME), correct = FALSE)
Q2.3$statistic # chiquadro
Q2.3$p.value  # pvalue

Q2.4= chisq.test (table (Dataset_new$Q2.4, Dataset_new$INCOME), correct = FALSE)
Q2.4$statistic # chiquadro
Q2.4$p.value  # pvalue

Q3.1= chisq.test (table (Dataset_new$Q3.1, Dataset_new$SEX), correct = FALSE)
Q3.1$statistic # chiquadro
Q3.1$p.value  # pvalue

Q3.2= chisq.test (table (Dataset_new$Q3.2, Dataset_new$SEX), correct = FALSE)
Q3.2$statistic # chiquadro
Q3.2$p.value  # pvalue

Q3.3= chisq.test (table (Dataset_new$Q3.3, Dataset_new$SEX), correct = FALSE)
Q3.3$statistic # chiquadro
Q3.3$p.value  # pvalue

Q3.4= chisq.test (table (Dataset_new$Q3.4, Dataset_new$SEX), correct = FALSE)
Q3.4$statistic # chiquadro
Q3.4$p.value  # pvalue

Q3.1= chisq.test (table (Dataset_new$Q3.1, Dataset_new$AGE), correct = FALSE)
Q3.1$statistic # chiquadro
Q3.1$p.value  # pvalue

Q3.2= chisq.test (table (Dataset_new$Q3.2, Dataset_new$AGE), correct = FALSE)
Q3.2$statistic # chiquadro
Q3.2$p.value  # pvalue

Q3.3= chisq.test (table (Dataset_new$Q3.3, Dataset_new$AGE), correct = FALSE)
Q3.3$statistic # chiquadro
Q3.3$p.value  # pvalue

Q3.4= chisq.test (table (Dataset_new$Q3.4, Dataset_new$AGE), correct = FALSE)
Q3.4$statistic # chiquadro
Q3.4$p.value  # pvalue
```

```
Q3.1= chisq.test (table (Dataset_new$Q3.1, Dataset_new$EDUCATION), correct = FALSE)
Q3.1$statistic # chiquadro
Q3.1$p.value  # pvalue

Q3.2= chisq.test (table (Dataset_new$Q3.2, Dataset_new$EDUCATION), correct = FALSE)
Q3.2$statistic # chiquadro
Q3.2$p.value  # pvalue

Q3.3= chisq.test (table (Dataset_new$Q3.3, Dataset_new$EDUCATION), correct = FALSE)
Q3.3$statistic # chiquadro
Q3.3$p.value  # pvalue

Q3.4= chisq.test (table (Dataset_new$Q3.4, Dataset_new$EDUCATION), correct = FALSE)
Q3.4$statistic # chiquadro
Q3.4$p.value  # pvalue

Q3.1= chisq.test (table (Dataset_new$Q3.1, Dataset_new$EMPLOYMENT), correct = FALSE)
Q3.1$statistic # chiquadro
Q3.1$p.value  # pvalue

Q3.2= chisq.test (table (Dataset_new$Q3.2, Dataset_new$EMPLOYMENT), correct = FALSE)
Q3.2$statistic # chiquadro
Q3.2$p.value  # pvalue

Q3.3= chisq.test (table (Dataset_new$Q3.3, Dataset_new$EMPLOYMENT), correct = FALSE)
Q3.3$statistic # chiquadro
Q3.3$p.value  # pvalue

Q3.4= chisq.test (table (Dataset_new$Q3.4, Dataset_new$EMPLOYMENT), correct = FALSE)
Q3.4$statistic # chiquadro
Q3.4$p.value  # pvalue

Q3.1= chisq.test (table (Dataset_new$Q3.1, Dataset_new$FAMILYSIZE), correct = FALSE)
Q3.1$statistic # chiquadro
Q3.1$p.value  # pvalue

Q3.2= chisq.test (table (Dataset_new$Q3.2, Dataset_new$FAMILYSIZE), correct = FALSE)
Q3.2$statistic # chiquadro
Q3.2$p.value  # pvalue

Q3.3= chisq.test (table (Dataset_new$Q3.3, Dataset_new$FAMILYSIZE), correct = FALSE)
Q3.3$statistic # chiquadro
Q3.3$p.value  # pvalue

Q3.4= chisq.test (table (Dataset_new$Q3.4, Dataset_new$FAMILYSIZE), correct = FALSE)
Q3.4$statistic # chiquadro
Q3.4$p.value  # pvalue

Q3.1= chisq.test (table (Dataset_new$Q3.1, Dataset_new$RESIDENCY), correct = FALSE)
Q3.1$statistic # chiquadro
Q3.1$p.value  # pvalue

Q3.2= chisq.test (table (Dataset_new$Q3.2, Dataset_new$RESIDENCY), correct = FALSE)
Q3.2$statistic # chiquadro
Q3.2$p.value  # pvalue

Q3.3= chisq.test (table (Dataset_new$Q3.3, Dataset_new$RESIDENCY), correct = FALSE)
Q3.3$statistic # chiquadro
Q3.3$p.value  # pvalue

Q3.4= chisq.test (table (Dataset_new$Q3.4, Dataset_new$RESIDENCY), correct = FALSE)
Q3.4$statistic # chiquadro
Q3.4$p.value  # pvalue
```

```
Q3.1= chisq.test (table (Dataset_new$Q3.1, Dataset_new$INCOME), correct = FALSE)
Q3.1$statistic # chiquadro
Q3.1$p.value  # pvalue

Q3.2= chisq.test (table (Dataset_new$Q3.2, Dataset_new$INCOME), correct = FALSE)
Q3.2$statistic # chiquadro
Q3.2$p.value  # pvalue

Q3.3= chisq.test (table (Dataset_new$Q3.3, Dataset_new$INCOME), correct = FALSE)
Q3.3$statistic # chiquadro
Q3.3$p.value  # pvalue

Q3.4= chisq.test (table (Dataset_new$Q3.4, Dataset_new$INCOME), correct = FALSE)
Q3.4$statistic # chiquadro
Q3.4$p.value  # pvalue

Q4= chisq.test (table (Dataset_new$Q4, Dataset_new$SEX), correct = FALSE)
Q4$statistic # chiquadro
Q4$p.value  # pvalue

Q4= chisq.test (table (Dataset_new$Q4, Dataset_new$AGE), correct = FALSE)
Q4$statistic # chiquadro
Q4$p.value  # pvalue

Q4= chisq.test (table (Dataset_new$Q4, Dataset_new$EDUCATION), correct = FALSE)
Q4$statistic # chiquadro
Q4$p.value  # pvalue

Q4= chisq.test (table (Dataset_new$Q4, Dataset_new$EMPLOYMENT), correct = FALSE)
Q4$statistic # chiquadro
Q4$p.value  # pvalue

Q4= chisq.test (table (Dataset_new$Q4, Dataset_new$FAMILYSIZE), correct = FALSE)
Q4$statistic # chiquadro
Q4$p.value  # pvalue

Q4= chisq.test (table (Dataset_new$Q4, Dataset_new$RESIDENCY), correct = FALSE)
Q4$statistic # chiquadro
Q4$p.value  # pvalue

Q4= chisq.test (table (Dataset_new$Q4, Dataset_new$INCOME), correct = FALSE)
Q4$statistic # chiquadro
Q4$p.value  # pvalue

Q5= chisq.test (table (Dataset_new$Q5, Dataset_new$SEX), correct = FALSE)
Q5$statistic # chiquadro
Q5$p.value  # pvalue

Q5= chisq.test (table (Dataset_new$Q5, Dataset_new$AGE), correct = FALSE)
Q5$statistic # chiquadro
Q5$p.value  # pvalue

Q5= chisq.test (table (Dataset_new$Q5, Dataset_new$EDUCATION), correct = FALSE)
Q5$statistic # chiquadro
Q5$p.value  # pvalue

Q5= chisq.test (table (Dataset_new$Q5, Dataset_new$EMPLOYMENT), correct = FALSE)
Q5$statistic # chiquadro
Q5$p.value  # pvalue

Q5= chisq.test (table (Dataset_new$Q5, Dataset_new$FAMILYSIZE), correct = FALSE)
Q5$statistic # chiquadro
Q5$p.value  # pvalue

Q5= chisq.test (table (Dataset_new$Q5, Dataset_new$RESIDENCY), correct = FALSE)
```

```
Q5$statistic # chiquadro
Q5$p.value  # pvalue

Q5= chisq.test (table (Dataset_new$Q5, Dataset_new$INCOME), correct = FALSE)
Q5$statistic # chiquadro
Q5$p.value  # pvalue

Q6= chisq.test (table (Dataset_new$Q6, Dataset_new$SEX), correct = FALSE)
Q6$statistic # chiquadro
Q6$p.value  # pvalue

Q6= chisq.test (table (Dataset_new$Q6, Dataset_new$AGE), correct = FALSE)
Q6$statistic # chiquadro
Q6$p.value  # pvalue

Q6= chisq.test (table (Dataset_new$Q6, Dataset_new$EDUCATION), correct = FALSE)
Q6$statistic # chiquadro
Q6$p.value  # pvalue

Q6= chisq.test (table (Dataset_new$Q6, Dataset_new$EMPLOYMENT), correct = FALSE)
Q6$statistic # chiquadro
Q6$p.value  # pvalue

Q6= chisq.test (table (Dataset_new$Q6, Dataset_new$FAMILYSIZE), correct = FALSE)
Q6$statistic # chiquadro
Q6$p.value  # pvalue

Q6= chisq.test (table (Dataset_new$Q6, Dataset_new$RESIDENCY), correct = FALSE)
Q6$statistic # chiquadro
Q6$p.value  # pvalue

Q6= chisq.test (table (Dataset_new$Q6, Dataset_new$INCOME), correct = FALSE)
Q6$statistic # chiquadro
Q6$p.value  # pvalue

Q7= chisq.test (table (Dataset_new$Q7, Dataset_new$SEX), correct = FALSE)
Q7$statistic # chiquadro
Q7$p.value  # pvalue

Q7= chisq.test (table (Dataset_new$Q7, Dataset_new$AGE), correct = FALSE)
Q7$statistic # chiquadro
Q7$p.value  # pvalue

Q7= chisq.test (table (Dataset_new$Q7, Dataset_new$EDUCATION), correct = FALSE)
Q7$statistic # chiquadro
Q7$p.value  # pvalue

Q7= chisq.test (table (Dataset_new$Q7, Dataset_new$EMPLOYMENT), correct = FALSE)
Q7$statistic # chiquadro
Q7$p.value  # pvalue

Q7= chisq.test (table (Dataset_new$Q7, Dataset_new$FAMILYSIZE), correct = FALSE)
Q7$statistic # chiquadro
Q7$p.value  # pvalue

Q7= chisq.test (table (Dataset_new$Q7, Dataset_new$RESIDENCY), correct = FALSE)
Q7$statistic # chiquadro
Q7$p.value  # pvalue

Q7= chisq.test (table (Dataset_new$Q7, Dataset_new$INCOME), correct = FALSE)
Q7$statistic # chiquadro
Q7$p.value  # pvalue
Q8= chisq.test (table (Dataset_new$Q8, Dataset_new$SEX), correct = FALSE)
Q8$statistic # chiquadro
Q8$p.value  # pvalue
```

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Q8= chisq.test (table (Dataset_new$Q8, Dataset_new$AGE), correct = FALSE)
Q8$statistic # chiquadro
Q8$p.value  # pvalue

Q8= chisq.test (table (Dataset_new$Q8, Dataset_new$EDUCATION), correct = FALSE)
Q8$statistic # chiquadro
Q8$p.value  # pvalue

Q8= chisq.test (table (Dataset_new$Q8, Dataset_new$EMPLOYMENT), correct = FALSE)
Q8$statistic # chiquadro
Q8$p.value  # pvalue

Q8= chisq.test (table (Dataset_new$Q8, Dataset_new$FAMILYSIZE), correct = FALSE)
Q8$statistic # chiquadro
Q8$p.value  # pvalue

vwQ8= chisq.test (table (Dataset_new$Q8, Dataset_new$RESIDENCY), correct = FALSE)
Q8$statistic # chiquadro
Q8$p.value  # pvalue

Q8= chisq.test (table (Dataset_new$Q8, Dataset_new$INCOME), correct = FALSE)
Q8$statistic # chiquadro
Q8$p.value  # pvalue

Q9= chisq.test (table (Dataset_new$Q9, Dataset_new$SEX), correct = FALSE)
Q9$statistic # chiquadro
Q9$p.value  # pvalue

Q9= chisq.test (table (Dataset_new$Q9, Dataset_new$AGE), correct = FALSE)
Q9$statistic # chiquadro
Q9$p.value  # pvalue

Q9= chisq.test (table (Dataset_new$Q9, Dataset_new$EDUCATION), correct = FALSE)
Q9$statistic # chiquadro
Q9$p.value  # pvalue

Q9= chisq.test (table (Dataset_new$Q9, Dataset_new$EMPLOYMENT), correct = FALSE)
Q9$statistic # chiquadro
Q9$p.value  # pvalue

Q9= chisq.test (table (Dataset_new$Q9, Dataset_new$FAMILYSIZE), correct = FALSE)
Q9$statistic # chiquadro
Q9$p.value  # pvalue

Q9= chisq.test (table (Dataset_new$Q9, Dataset_new$RESIDENCY), correct = FALSE)
Q9$statistic # chiquadro
Q9$p.value  # pvalue


Q9= chisq.test (table (Dataset_new$Q9, Dataset_new$INCOME), correct = FALSE)
Q9$statistic # chiquadro
Q9$p.value  # pvalue

Q10= chisq.test (table (Dataset_new$Q10, Dataset_new$SEX), correct = FALSE)
Q10$statistic # chiquadro
Q10$p.value  # pvalue

Q10= chisq.test (table (Dataset_new$Q10, Dataset_new$AGE), correct = FALSE)
Q10$statistic # chiquadro
Q10$p.value  # pvalue

Q10= chisq.test (table (Dataset_new$Q10, Dataset_new$EDUCATION), correct = FALSE)
Q10$statistic # chiquadro
Q10$p.value  # pvalue
```

```
Q10= chisq.test (table (Dataset_new$Q10, Dataset_new$EMPLOYMENT), correct = FALSE)
Q10$statistic # chiquadro
Q10$p.value  # pvalue

Q10= chisq.test (table (Dataset_new$Q10, Dataset_new$FAMILYSIZE), correct = FALSE)
Q10$statistic # chiquadro
Q10$p.value  # pvalue

Q10= chisq.test (table (Dataset_new$Q10, Dataset_new$RESIDENCY), correct = FALSE)
Q10$statistic # chiquadro
Q10$p.value  # pvalue

Q10= chisq.test (table (Dataset_new$Q10, Dataset_new$INCOME), correct = FALSE)
Q10$statistic # chiquadro
Q10$p.value  # pvalue

Q11= chisq.test (table (Dataset_new$Q11, Dataset_new$SEX), correct = FALSE)
Q11$statistic # chiquadro
Q11$p.value  # pvalue

Q11= chisq.test (table (Dataset_new$Q11, Dataset_new$AGE), correct = FALSE)
Q11$statistic # chiquadro
Q11$p.value  # pvalue

Q11= chisq.test (table (Dataset_new$Q11, Dataset_new$EDUCATION), correct = FALSE)
Q11$statistic # chiquadro
Q11$p.value  # pvalue

Q11= chisq.test (table (Dataset_new$Q11, Dataset_new$EMPLOYMENT), correct = FALSE)
Q11$statistic # chiquadro
Q11$p.value  # pvalue

Q11= chisq.test (table (Dataset_new$Q11, Dataset_new$FAMILYSIZE), correct = FALSE)
Q11$statistic # chiquadro
Q11$p.value  # pvalue

Q11= chisq.test (table (Dataset_new$Q11, Dataset_new$RESIDENCY), correct = FALSE)
Q11$statistic # chiquadro
Q11$p.value  # pvalue

Q11= chisq.test (table (Dataset_new$Q11, Dataset_new$INCOME), correct = FALSE)
Q11$statistic # chiquadro
Q11$p.value  # pvalue

Q12= chisq.test (table (Dataset_new$Q12, Dataset_new$SEX), correct = FALSE)
Q12$statistic # chiquadro
Q12$p.value  # pvalue

Q12= chisq.test (table (Dataset_new$Q12, Dataset_new$AGE), correct = FALSE)
Q12$statistic # chiquadro
Q12$p.value  # pvalue

Q12= chisq.test (table (Dataset_new$Q12, Dataset_new$EDUCATION), correct = FALSE)
Q12$statistic # chiquadro
Q12$p.value  # pvalue

Q12= chisq.test (table (Dataset_new$Q12, Dataset_new$EMPLOYMENT), correct = FALSE)
Q12$statistic # chiquadro
Q12$p.value  # pvalue

Q12= chisq.test (table (Dataset_new$Q12, Dataset_new$FAMILYSIZE), correct = FALSE)
Q12$statistic # chiquadro
Q12$p.value  # pvalue
```

```
Q12= chisq.test (table (Dataset_new$Q12, Dataset_new$RESIDENCY), correct = FALSE)
Q12$statistic # chiquadro
Q12$p.value  # pvalue

Q12= chisq.test (table (Dataset_new$Q12, Dataset_new$INCOME), correct = FALSE)
Q12$statistic # chiquadro
Q12$p.value  # pvalue

Q13= chisq.test (table (Dataset_new$Q13, Dataset_new$SEX), correct = FALSE)
Q13$statistic # chiquadro
Q13$p.value  # pvalue

Q13= chisq.test (table (Dataset_new$Q13, Dataset_new$AGE), correct = FALSE)
Q13$statistic # chiquadro
Q13$p.value  # pvalue

Q13= chisq.test (table (Dataset_new$Q13, Dataset_new$EDUCATION), correct = FALSE)
Q13$statistic # chiquadro
Q13$p.value  # pvalue

Q13= chisq.test (table (Dataset_new$Q13, Dataset_new$EMPLOYMENT), correct = FALSE)
Q13$statistic # chiquadro
Q13$p.value  # pvalue

Q13= chisq.test (table (Dataset_new$Q11, Dataset_new$FAMILYSIZE), correct = FALSE)
Q13$statistic # chiquadro
Q13$p.value  # pvalue

Q13= chisq.test (table (Dataset_new$Q13, Dataset_new$RESIDENCY), correct = FALSE)
Q13$statistic # chiquadro
Q13$p.value  # pvalue

Q13= chisq.test (table (Dataset_new$Q13, Dataset_new$INCOME), correct = FALSE)
Q13$statistic # chiquadro
Q13$p.value  # pvalue

Q14= chisq.test (table (Dataset_new$Q14, Dataset_new$SEX), correct = FALSE)
Q14$statistic # chiquadro
Q14$p.value  # pvalue

Q14= chisq.test (table (Dataset_new$Q14, Dataset_new$AGE), correct = FALSE)
Q14$statistic # chiquadro
Q14$p.value  # pvalue

Q14= chisq.test (table (Dataset_new$Q14, Dataset_new$EDUCATION), correct = FALSE)
Q14$statistic # chiquadro
Q14$p.value  # pvalue

Q14= chisq.test (table (Dataset_new$Q14, Dataset_new$EMPLOYMENT), correct = FALSE)
Q14$statistic # chiquadro
Q14$p.value  # pvalue

Q14= chisq.test (table (Dataset_new$Q14, Dataset_new$FAMILYSIZE), correct = FALSE)
Q14$statistic # chiquadro
Q14$p.value  # pvalue

Q14= chisq.test (table (Dataset_new$Q14, Dataset_new$RESIDENCY), correct = FALSE)
Q14$statistic # chiquadro
Q14$p.value  # pvalue

Q14= chisq.test (table (Dataset_new$Q14, Dataset_new$INCOME), correct = FALSE)
Q14$statistic # chiquadro
Q14$p.value  # pvalue

Q15= chisq.test (table (Dataset_new$Q15, Dataset_new$SEX), correct = FALSE)
```

```
Q15$statistic # chiquadro
Q15$p.value  # pvalue

Q15= chisq.test (table (Dataset_new$Q15, Dataset_new$AGE), correct = FALSE)
Q15$statistic # chiquadro
Q15$p.value  # pvalue

Q15= chisq.test (table (Dataset_new$Q15, Dataset_new$EDUCATION), correct = FALSE)
Q15$statistic # chiquadro
Q15$p.value  # pvalue

Q15= chisq.test (table (Dataset_new$Q15, Dataset_new$EMPLOYMENT), correct = FALSE)
Q15$statistic # chiquadro
Q15$p.value  # pvalue

Q15= chisq.test (table (Dataset_new$Q15, Dataset_new$FAMILYSIZE), correct = FALSE)
Q15$statistic # chiquadro
Q15$p.value  # pvalue

Q15= chisq.test (table (Dataset_new$Q15, Dataset_new$RESIDENCY), correct = FALSE)
Q15$statistic # chiquadro
Q15$p.value  # pvalue

Q15= chisq.test (table (Dataset_new$Q15, Dataset_new$INCOME), correct = FALSE)
Q15$statistic # chiquadro
Q15$p.value  # pvalue

Q16= chisq.test (table (Dataset_new$Q16, Dataset_new$SEX), correct = FALSE)
Q16$statistic # chiquadro
Q16$p.value  # pvalue

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Q16$p.value  # pvalue

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Q16$p.value  # pvalue

Q16= chisq.test (table (Dataset_new$Q16, Dataset_new$RESIDENCY), correct = FALSE)
Q16$statistic # chiquadro
Q16$p.value  # pvalue

Q16= chisq.test (table (Dataset_new$Q16, Dataset_new$INCOME), correct = FALSE)
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```

Summary

Introduction

The rapid increase in electrical and electronic equipment consumption due to the technological revolution and consumer demand presents a global challenge of household e-waste. The shorter lifespan of products and the disposal of obsolete appliances contribute to waste and CO2 emissions, exacerbating the instability in the global living biomass. The Circular Economy (CE), based on the principles of reduction, reuse, recovery, and recycling, offers a regenerative system to minimize waste and pollution. E-waste management is crucial as it contains hazardous and valuable resources that can be recycled and remanufactured. However, the recycling rates in Europe are below the target, including Portugal, where the per capita collection of WEEE is low. This study aims to understand consumers consumption, disposal and awareness behaviors related to e-waste management in Portugal to develop strategies for increasing collection rates.

Literature Review

The literature review is going to be structured into four sections. The first section aims to give an overview of the European and Portuguese legislation regarding e-waste. The other three section focuses on consumer behaviors towards consumption, disposal, and awareness of household e-waste.

The European legislation, Directive 2021/19/EU, defines electrical and electronic equipment (EEE) and waste derived from it (WEEE). The directive classifies items into six categories and addresses hazardous substances present in EEE. The recycling of WEEE is challenging due to the variety of materials and hazardous nature of the substances. The directive emphasizes minimizing disposal in unsorted municipal waste and achieving high levels of separate collection. Member states are responsible for ensuring collection facilities' accessibility and availability. The directive introduces the principle of Producer Responsibility, setting collection and separate collection rates. Producers must establish and finance collection systems, while distributors must enable free return of waste when supplying new products. Distributors must also allow small WEEE collection at retail stores. Member states are required to provide information to users regarding waste disposal, collection systems, and environmental and health impacts. The volume of EEE released onto the market in the European Union increased over the years, with a record of 12.4 million tonnes in 2020. The amount of treated and collected WEEE also increased, showing positive trends in recycling and reuse.

The Portuguese legislation regarding e-waste is “Decreto-Lei n. º 102-D/2020”. The law emphasizes the principle of health prevention in waste management, aiming to minimize adverse environmental and health impacts. It establishes extended producer responsibility, requiring producers and importers of electronic and electric equipment to finance the collection and treatment of waste from their products. This responsibility can be assumed individually or transferred to integrated systems, whether private or public. Three waste management collective systems, namely Electrão (previously known as AMB3E), ERP Portugal, and

WEEECYCLE, have been implemented to fulfill these measures since 2006. The national targets for waste collection and recovery have progressively increased, with a focus on waste prevention, reuse preparation, recycling, valorization, and disposal. The legislation also encourages consumers to adopt practices promoting product and material reuse, while waste producers are urged to implement preventive measures, including waste source separation. Effective waste management plans have been developed in collaboration with municipalities, inter-municipalities, and multi-municipalities. The Agência Portuguesa do Ambiente (APA) and Entidade Reguladora dos Serviços de Águas e Resíduos (ERSAR) oversee the implementation of European directives in Portugal. Citizens have a vital role in separating and depositing e-waste at designated collection points, and non-compliance can lead to specific administrative offenses. Municipal systems are required to conduct awareness campaigns to encourage waste reduction and communicate the benefits of proper e-waste management to citizens.

Moving on, the growing consumption of electrical and electronic equipment (EEE) and the subsequent increase in waste generation. It points out the inefficiency of waste management systems both at the European and national levels, where the amount of EEE put on the market per person exceeds the amount of waste collected. Portugal has particularly low collection rates compared to other European countries, despite a rise in per capita EEE consumption. Ownership rates of EEE vary based on sociodemographic characteristics. Cooling and freezing equipment comprise the largest proportion of waste, followed by small and large household appliances. The preference for purchasing new equipment over repair is driven by perceived technological obsolescence rather than actual malfunction. The culture of reuse, repair, and second-hand sales is still underdeveloped in many European countries. The technical condition of items also influences the decision to replace them, with factors such as out-of-date functionalities and dead batteries playing a significant role. The text emphasizes the need to address these challenges and promote sustainable practices such as reuse and repair to mitigate the environmental impact of EEE consumption and waste generation.

In addition, the literature review discusses the issue of electronic waste (e-waste) disposal and the challenges involved in managing it. It emphasizes the need to understand consumer behavior and disposal patterns to improve waste collection systems. The main problem highlighted is that a significant amount of e-waste is not properly disposed of through official channels, leading to environmental hazards and illegal waste trading. The focus is on the situation in Portugal, where the legislation is still lacking a comprehensive approach and the requirement for proper handover of Waste Electrical and Electronic Equipment (WEEE). Producer Responsibility Organizations (PROs) support these ideas and advocate for their implementation as crucial policies. The text outlines various options available to Portuguese consumers, including the "um-para-um" approach of exchanging old equipment when purchasing new ones, as well as dedicated acceptance points established by PROs and municipalities. The importance of awareness campaigns and initiatives is highlighted, such as the "a recolha de monstros" campaign in Cascais municipality and the "Porta a Porta"

project, which collects e-waste directly from people's homes. The text also mentions the tendency of consumers to store small electric appliances due to reasons like emotional attachment. It suggests that analyzing common incentives for citizens and their preferences can positively influence proper disposal practices.

Finally, consumer resistance towards e-waste stems from a lack of environmental awareness regarding the harmful consequences of improper disposal. Insufficient knowledge about the toxicity of e-waste and sociodemographic factors contribute to consumer reluctance to participate in e-waste take-back systems. Recycling e-waste is crucial for a circular economy as it allows for the recovery of valuable materials while preventing the release of hazardous substances. Raising consumer awareness about e-waste is essential to address these issues, as unawareness leads to improper disposal and the preference for selling e-waste rather than recycling it. In Portugal, Electrão and non-governmental organizations have implemented awareness campaigns, while the municipality of Cascais is yet to initiate a specific e-waste awareness campaign. The APA and ERP have also conducted surveys and launched campaigns to encourage proper disposal and emphasize the importance of responsible recycling. Increasing consumer awareness and implementing effective campaigns are vital for fostering a positive attitude towards e-waste and promoting responsible recycling practices for a circular economy.

The study highlights the importance of e-waste management and its impact on human well-being. Consumer behavior in relation to e-waste has received limited attention, with only a few countries exploring its significance. Previous research mainly focused on specific aspects of consumer behavior, such as knowledge, storage, disposal, repair, reuse, and recycling. Additionally, studies often examined specific waste streams rather than considering all categories of household e-waste. This research aims to analyze the current consumption, disposal, and awareness trends of Portuguese consumers regarding household e-waste. The study seeks to determine the association between consumer behavior and sociodemographic characteristics. The research questions focus on the amount of household electric and electronic equipment, consumption behavior, disposal behavior, and awareness regarding recycling. This study is unique as it contributes to an important area of research that has been neglected in developed countries. It also adds to the limited body of research conducted in Portugal. The findings can benefit companies, policymakers, and municipalities by informing product design, promoting responsible disposal practices, and targeting awareness campaigns to specific consumer groups. Ultimately, the study aims to improve the collection rate of household e-waste and encourage sustainable behavior.

Methodology

This chapter provides a detailed explanation of the research methods employed in the study. It aims to enhance understanding and engagement with the research process while ensuring the reliability and validity of the reported findings. The methodology, design, data collection methods, and analysis procedures are carefully outlined.

In section 3.1, two experts were interviewed to gain insights into the subject matter. The first expert, the CEO of a Portuguese e-waste management company, emphasized the importance of understanding how Portuguese consumers recycle and dispose of their household e-waste. Factors such as sociodemographic elements (e.g., education and employment) were considered relevant for studying consumers' behavior and awareness. This information could help policymakers tailor interventions to specific needs.The second expert, working for Cascais Ambiente in the administrative office, suggested that Portuguese consumers often fail to dispose of household items correctly due to a lack of incentive measures. She proposed implementing incentives such as discounts, cash back systems, or new take-back systems for large equipment.

In section 3.2, an online survey was conducted using snowball sampling as the method. The survey was shared through the university's association, colleagues, and social media, encouraging participants to share the questionnaire with their networks. Google Forms, a free online tool, was utilized for data collection. Snowball sampling was deemed suitable for this explanatory research as it enabled quick recruitment of participants from various geographical areas at a low cost. The survey was anonymous to avoid negative social bias and remained open from March 11th to April 11th, 2023. A total of 218 valid responses were received and considered for analysis. The survey questions were developed based on existing literature and suggestions from the experts. Content validity was ensured by involving academic and professional experts in the field.
In section 3.3, the study utilized a questionnaire consisting of 23 questions administered in Portuguese to ensure respondent understanding. The questionnaire was divided into five parts, covering sociodemographic information, consumption behavior, disposal practices, and environmental awareness regarding household e-waste. It explored aspects such as ownership, lifespan, and second-hand purchases of different types of equipment. It also examined disposal methods, reasons for storage, knowledge of disposal options provided by producer responsibility organizations, willingness to participate in door-to-door collection, and preferences for incentives. Additionally, the questionnaire assessed respondents' environmental awareness, including knowledge of e-waste's environmental damages, relevant laws, valuable materials, proper disposal, and recycling importance. The questions aimed to collect both qualitative and quantitative data through multiple-choice and Likert scale responses.

In section 3.4, the survey data was pre-processed using Microsoft Excel and CVS. This involved translating the questions into English and abbreviating them for easier data processing in R-studio. The dataset was checked for missing values, and adjustments were made to ensure completeness. In section 3.5, the statistical

analysis was conducted using R-studio. The chi-square test was utilized to determine significant associations between categorical variables. A significant p-value ($p < 0.05$) indicated a statistically significant relationship between the variables, while a non-significant p-value ($p > 0.05$) indicated insufficient evidence to reject the null hypothesis. The research aimed to test the dependence between consumption, disposal, and awareness (response variables) and sociodemographic variables such as sex, age, education, residency, employment, family income, and family size. The survey questions were grouped into three categories: consumption, disposal, and awareness.

Findings

The findings have been structured in two parts. The first part is descriptive findings, which aim at analyzing the current trends, while the second part analyzed the statistical findings.

The survey was completed by a total of 218 participants. The demographic data reveals that 62% of the participants were female, while 38% were male. The age distribution shows that the highest percentage falls within the 17-25 years old age group. Most participants (79%) have university degrees, with 19% having high school degrees. In terms of employment, 35% identified as students, 44% as employed full-time, 8% as employed part-time, 11% as owners, and the remainder as unemployed. The survey indicates that families with 3 to 4 members represent the highest distribution (60%). Most respondents were from the Lisbon area (51%). In terms of household income, the largest portion (29.4%) falls within the 10-20k range, while the lowest percentage (7.3%) is for those earning over 60K.

The survey explored the consumption behavior of Portuguese consumers in terms of the number of items owned and their purchasing habits. Regarding IT and Telecommunication equipment, 38% of respondents reported having more than four objects, 35% had between 3 and 4, while the remainder had between 1 and 2. In terms of TVs, 45% of respondents had more than 4, while only 24% had between 1 and 2. Similarly, for small appliances like irons or vacuum cleaners, 45% had more than 4 items, 29% had between 3 and 4, and the rest had between 1 and 2. In the category of large EEE (Electrical and Electronic Equipment), 45% had more than 4 items. When it comes to purchasing second-hand items, more than 50% of respondents in all categories reported never buying second-hand. However, over 25% of respondents had bought between 1 and 2 second-hand items. In terms of the duration before replacing an item, more than 75% of respondents replaced their consumption and large equipment after 4 years. For IT equipment, the majority (42%) replaced it after 3 to 4 years, while for small appliances, 48% replaced them after 3 to 4 years. The primary reason for replacing equipment was due to it being broken, cited by 80% of respondents, while the rest mentioned replacing it for a new model. When asked about alternatives to a broken item, 36% of respondents preferred repairing it due to cost considerations, 32% would buy a new one at a discounted price, 18% would opt for the latest model, and 14% would choose to repair it.

The survey examines the consumption behavior of Portuguese consumers based on the number of items they own and their purchasing habits. Regarding IT and Telecommunication equipment, 38% of respondents reported having more than four objects, 35% had between 3 and 4, and the remaining participants had between 1 and 2. In terms of TVs, 45% of respondents had more than 4, while only 24% had between 1 and 2. Similarly, for small appliances such as irons or vacuum cleaners, 45% had more than four items, 29% had between 3 and 4, and the rest had between 1 and 2. For large Electrical and Electronic Equipment (EEE), 45% of respondents had more than 4 items. When it comes to purchasing second-hand items, over 50% of respondents in all categories stated that they had never bought second-hand. However, more than 25% of participants had purchased between 1 and 2 second-hand items. In terms of the duration before replacing an item, more than 75% of respondents replaced their consumption and large equipment after four years. Regarding IT equipment, 42% of respondents replaced it after 3 to 4 years, while for small appliances, the figure was 48% after 3 to 4 years. The primary reason for equipment replacement was due to it being broken, as reported by 80% of respondents, while the remaining participants mentioned replacing it for a new model. When asked about alternative solutions for a broken item, 36% of respondents preferred repairing it due to cost considerations, 32% would buy a new one at a discounted price, 18% would opt for the latest model, and 14% would choose to repair it.

The survey explored the disposal behavior of Portuguese consumers in relation to electronic waste (e-waste) and their knowledge of waste management systems. When it comes to general disposal behavior, the majority of respondents store e-waste at home (44%) or take it to formal collection points (47%). A minority of participants dispose of e-waste in the mixed waste bin (6%) or leave it at the front door (3%). Regarding the disposal of large equipment, most people (63%) prefer to give it to formal collection points. However, 19% leave it at the front door, 15% store it at home, and the rest dispose of it in the mixed waste bin. The reasons for storing e-waste vary, with the prevailing trend (48%) being that people believe it may be useful in the future. Other reasons include indifference towards disposal (24%), sentimental attachment (21%), and lack of space issues. The survey reveals that a significant percentage of respondents still do not dispose of their e-waste but instead choose to store it within their households for various purposes. In terms of knowledge about Portuguese waste management organizations (PROs), 33% have full knowledge, 27% have medium knowledge, and the remaining participants have little knowledge. Regarding the possibility of door-to-door e-waste collection organized by municipalities at least once a month, 59% of respondents find it functional and useful, while 34% appreciate it because they do not have to go to collection points. When it comes to preferred incentive methods, most Portuguese citizens (36%) prefer discounts when purchasing new environmentally friendly items. A cash-back incentive system is favored by 35% of respondents, a minority (19%) prioritize environmental concerns over incentives, and the rest prefer tax discounts.

The survey examines the awareness behavior of Portuguese consumers in relation to electric and electronic appliances, toxic materials, laws, valuable materials, disposal effects, and the importance of recycling. Awareness of toxic materials inside electric and electronic appliances: 42% of respondents are fully aware, 30% are moderately aware, 13% have some awareness, and the remaining participants are not aware. Awareness of Portuguese and European laws regarding electric and electronic appliances: 65% of respondents need to be made aware, while only 6% are fully aware.Knowledge of valuable materials found inside electric and electronic appliances: 36% are fully aware, 22% are moderately aware, 28% have some awareness, and 11% are not aware. Awareness of the effects of throwing electric and electronic appliances into the mixed waste bin: 29% are fully aware, 25% are moderately aware, 26% have some awareness, and 20% are not aware. Understanding the importance of recycling: 49% are fully aware, 33% are moderately aware, 13% have some awareness, and the remaining participants are unaware.

The statistical analysis focused on examining the association between sociodemographic characteristics and consumption behavior, disposal behavior, and awareness behavior related to electric and electronic appliances. In terms of consumption behavior, age, employment, family size, and income were found to be significantly associated with possession of IT and telecommunication equipment. Younger respondents and households with more family members had a higher number of such items. Age and income also influenced the possession of consumer equipment like TVs, with older respondents and higher income individuals owning more. There was a trend of students and unemployed individuals being more inclined to buy second-hand equipment, while full-time workers preferred new products.

Regarding disposal behavior, age, employment, family size, residency, and income played important roles. Older respondents tended to store small appliances, while younger respondents preferred formal collection points. Family size and income influenced the choice of disposal method, with larger households and higher-income households more likely to use formal collection points. Age, employment, and residency also affected the disposal of large appliances, with different groups exhibiting different tendencies.

Awareness behavior analysis showed that education and family size were associated with knowledge of toxic elements in appliances. Respondents with university degrees and larger households demonstrated higher awareness. Knowledge of e-waste legislation was influenced by age, education, employment, family size, and residency. Younger respondents and those with higher education levels had better knowledge. The awareness of valuable materials in appliances was linked to age, employment, and residency. The effects of throwing e-waste in the mixed waste bin were more apparent to younger respondents, those with higher education, and higher income levels. Women showed a greater inclination towards recycling and separation of e-waste compared to men, and younger respondents and those from specific regions displayed a higher importance placed on recycling.

Discussion and Recommendation

The study found that Portuguese consumers follow similar trends as observed in the literature, with larger and temperature exchange equipment being present in households with four or more members. Younger respondents were found to possess and consume more items, indicating a need for educational strategies targeting impulsive buying among students. Furthermore, a significant percentage of consumers preferred buying second-hand equipment, particularly students, owners, and unemployed individuals. Policymakers were recommended to encourage sustainable consumption patterns, promote the second-hand market, and offer smart repairing services.

Regarding disposal, the research revealed that most Portuguese consumers store small items at home, but students were more likely to use formal collection points. The study suggested increasing disposal options around universities and cities while also raising awareness about the impact of storing items. Large items were primarily brought to formal collection systems, but a substantial proportion of the population left them in front of their doors, indicating inefficiencies in current initiatives. It was recommended to create more convenient collection points and tailor disposal messages to different age groups. Door-to-door collection methods were highly appreciated by respondents, suggesting its implementation on a larger scale. Financial rewards and incentives for returning end-of-life products were favored by Portuguese consumers.

Regarding awareness, the study found that Portuguese citizens had a moderate understanding of toxic materials in e-waste, with higher levels of awareness among educated individuals. Consumers were more concerned about the toxicity of e-waste than its potential for reuse. Regional differences in awareness were observed, emphasizing the need for localized interventions. Knowledge of national and European legislation was found to be low, indicating the necessity for government efforts to communicate these laws. The study highlighted the importance of enhancing knowledge and awareness among the population, particularly through educational campaigns, with a focus on women and socioeconomic groups. Financial incentives and legislation were suggested to promote proper disposal and recycling practices.

In conclusion, this research identified factors associated with Portugal's low household e-waste collection rate, including consumption patterns, disposal behaviors, and awareness levels. The findings provided valuable insights for policymakers and stakeholders to develop strategies aimed at promoting sustainable consumption, increasing the second-hand market, improving disposal systems, and enhancing public awareness of the importance of recycling household e-waste.

Conclusions

- Large and temperature exchange equipment are commonly found in Portuguese households from 4 onwards, aligning with market forecasts and environmental research on the necessity of cooling and freezing equipment.
- Younger respondents tend to possess and consume more IT and telecommunication equipment, highlighting the need for proactive strategies in educational institutions to raise awareness about the negative impact of impulsive buying.
- Age and income are significant factors associated with TV consumption and small equipment, emphasizing the importance of tailored approaches to address these demographics.
- A substantial percentage (25%) of consumers, particularly students, opt to purchase secondhand household equipment, indicating a growing awareness of the environmental benefits of buying used items.
- Policymakers can promote sustainable consumption patterns through awareness campaigns, incentivizing repair services, and advocating for the purchase of energy-efficient and long-lasting products.
- Collaboration between policymakers and industry stakeholders can further promote the secondhand market by implementing tax incentives or subsidies for used goods, fostering a circular economy model.
- Companies can tap into the secondhand market by developing strategies to cater to this consumer segment, such as offering innovative repairing services to encourage item repair instead of immediate replacement.
- Disposal points around universities and cities prove to be effective in encouraging proactive disposal behavior among students.
- Increasing the number of convenient disposal options around cities and workplaces is recommended to improve disposal rates.
- Respondents need more awareness about the negative impact of storing items at home, leading to resource waste and environmental problems.
- Proper awareness campaigns are necessary to educate the public about disposal sites and encourage correct e-waste disposal.
- Tailoring messages about the significance of proper e-waste disposal to different age groups is crucial, especially for older respondents who tend to store items.
- All socioeconomic groups should have equal access to appropriate e-waste disposal solutions.
- Consumers appreciate door-to-door collection methods as they are convenient and practical, indicating the need for better implementation by municipalities.
- Establishing regular collection days for household appliances and avoiding needing a 48-hour call can improve efficiency and prevent scavenging.

- Financial rewards and incentives, such as discounts on new green items, encourage participation in e-waste treatment and should be further implemented.
- The level of awareness among Portuguese citizens regarding toxic materials in e-waste is moderate and can be increased, particularly among more educated individuals.
- Citizens are more concerned about the toxicity of e-waste than its potential for reuse, highlighting the need for awareness campaigns focusing on both aspects.
- Tailored interventions, localized awareness campaigns, education initiatives, and infrastructure development are needed in regions with lower awareness levels.
- Greater awareness of the harmful effects of throwing e-waste in mixed waste bins is observed among more educated and prosperous respondents.
- Knowledge of National and European legislation regarding e-waste disposal could be higher, emphasizing the need for improved communication and educational campaigns.
- Increasing awareness among the Portuguese population, especially women who are more likely to recycle, can be achieved through financial incentives and legislation.
- Proper disposal and recycling practices can be promoted through measures that make improper disposal more expensive or provide incentives for collection and recycling.