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What factors influence consumers' repair and replacement propensities in the Belgian smartphone sector?

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Abstract:

This master's thesis explores the different factors that consumers face when they want to repair a product in order to extend its lifecycle. Typically, when your smartphone breaks, you have two options: repair it or replace it by buying a new device. When faced with this decision, there are many factors to consider, such as the price difference, the time and effort involved, and the environmental concerns associated with the production of this small device. The total pollution generated by a smartphone is huge, and the production phase alone accounts for 80% of its ecological footprint. It is in this context, and with a desire to strengthen the Circular Economy, that the Right to Repair movement has emerged. It aims to increase consumers' autonomy in the marketplace by enabling them to decide what they want to do with their products. Consumers are responsible for repairing a product or buying a new one, but they are independent of how the product is designed by manufacturers. In 2019, the European Union adopted the "Right to Repair Directive", which enables consumers to make better decisions about their defective products. Through a literature review, we developed a theoretical framework comprising 19 theoretical factors influencing consumers' decision between repair and replacement, and classified them into four categories. Qualitative and quantitative studies were conducted on Belgian smartphone owners to assess the significance of these factors. The results of the study have revealed that economic attachment, consumer's age, repair time and efforts, and factors related to repair services are the most important factors affecting consumers' decision to repair or replace their smartphone. The findings have also shown that the factor related to environmental concerns is slightly significant. On this basis, seven solutions are proposed to promote the Circular Economy through increasing the number of repair actions. This master's thesis and its theoretical framework can serve as a basis for future research aimed at testing consumer attitudes to repair.

Keywords: Repair propensity, Replacement propensity, Right to Repair, Circular Economy, Factors/barriers, Smartphones, Final consumers, Environment, (e)-waste

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Forewords

After eight conscientious and rigorous months of work on this master's thesis, we are proud to present it to you. However, none of this would have been possible without the help of many people.

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1. Introduction

Imagine you have recently purchased a new smartphone and the screen breaks. Being in a society where topics such as sustainable and Circular Economy have grown significantly, you decide to take steps to repair it. However, you realize that repairing your smartphone is relatively expensive compared to replacing it with a new one. The dilemma you are facing is the following: do you proceed with the repair, knowing that the price for the same new product is substantially the same as the price to repair it? This dilemma is not fiction but happens in real life. A recent article from RTL info. (2023) illustrated a young man having to pay 750€ to replace the broken screen of his smartphone that he purchased less than two years ago. He explained that from a financial point of view, it would be more advantageous for him to replace his smartphone than to repair it. Moreover, this young man is not entitled to the legal warranty because even if the smartphone is less than two years old, according to the technicians, it would have a small blow on the screen which would explain why the screen came completely off. However, he disagrees with the diagnostic and claims that the companies make consumers opting for replacement by directly demonstrating that the breakage came from the consumer and not from the normal use of the product. This dilemma that a consumer faces when its smartphone breaks, does not only occur on this type of product. In another recent article published by RTL info. (2023), the washing machine of a Belgian consumer breaks down and the price to repair it is the same as buying a new one. He did not want to replace it and called a technician in order to get a diagnostic and be able to quickly reuse it. The amount of the quotation, excluding the work labour, was 300€. The technician told him that if he added the labour work to the quotation, the final amount would be higher than a new washing machine. This Belgian consumer wondering about overconsumption, testifies: «We've been talking for decades about global warming, over-consumption and programmed obsolescence. We should buy less new and repair more. But here, everything encourages us to buy new when an appliance no longer works. That's a problem for me as a global citizen» (Translation from RTL info, 2023). According to the same article, the reporter went to ask the CEO of a store specializing in household appliances about why the repair cost is higher than a new product. The CEO answered that in most cases, the price of spare parts could represent 30% of the price of a new product, and when you add to the bill the labour work and the logistics, the total amount is higher than a new product.

Like all sectors, the smartphone industry is subject to numerous regulations but what about the repair laws in Europe? Recently, Le Soir (2024) reported that Members of the European Parliament have voted in favour of new regulations that encourage consumers to repair their defective products as smartphones instead of buying new ones. This new legislation includes the « Right to Repair », which enables consumers to request repairs for products even after the warranty has expired. Moreover, the text proposes the creation of online platforms to help consumers find repairers or sellers of reconditioned products, reducing costs and increasing competition in the repair market. The legislation also aims to improve access to spare parts, tools and information needed for repairs. According to a study by the European

Commission, cited in Le Soir (2024), 77% of European citizens prefer repairing their products over buying new ones. Indeed, buying new products instead of repairing old ones cost consumers around 12 billion euros annually. From an environmental point of view, discarded repairable products generate approximately 35 million tonnes of waste in the EU each year, causing significant environmental damage (Le Soir, 2024).

It is now widely recognized that human activities are the major cause of climate change, and the smartphone industry is no exception. This sector has experienced strong growth in recent years. Between 2007 and 2017, more than 7 billion smartphones were produced, as shown in Figure 1. Since the beginning of the 21st century and the advent of smartphones, the number of people who own one has increased considerably. In fact, in 2016, 1,4 billion smartphones were sold, compared with just 120 million in 2007 (Jardim, 2017). Since then, more or less 1,5 billion smartphones are bought worldwide every year (Ekwateur, 2023). So far, nothing very problematic, but that's without counting the negative impact and the disastrous ecological footprint this little device has on our environment. According to manufacturers' figures, an iPhone releases between 50 and 76 kg of CO2 into the atmosphere, while for Samsung this can vary between 22 and 70 kg depending on the smartphone (Ekwateur, 2023). As these numbers come from the companies themselves, the carbon footprint of a smartphone is certainly still rising, and can even reach 100 kg of CO2 (Six, 2023). This phenomenon has intensified in recent years with the production of smartphones with ever larger screens, as the environmental impact is even bigger as screen size increases (Kroutchinin & Baudrier, 2019). In fact, according to some studies, a smartphone larger than 5,5 inches releases 5 kg more than a smaller screen (Ekwateur, 2023). To give you an order of magnitude, Apple's iPhone 16, scheduled for release in September 2024, is expected to contain a screen of up to 6,9 inches (Patrelle, 2023). Another big issue with smartphones is their very short lifetime. Whether in France or the USA, even if this figure is improving, the average lifespan of a smartphone is around two years (Dufour, 2017). In addition to creating a huge amount of electronic waste, the big problem is that the production phase of a smartphone, including the extraction of raw materials, is on its own responsible for 70 to 80% of the total pollution of this electronic device, making it the most carbon-intensive phase (Jardim, 2017). Behind this phase, the pollution from the assembly of a smartphone seems almost anecdotal, even though it takes four world tours to produce it. Design is based in the USA, raw materials are extracted in Africa, Asia and Australia, components are manufactured in Asia, the USA and Europe, assembled in Asia and distributed worldwide. This represents almost 20% of a smartphone's total pollution (Ekwateur, 2023). Some studies have shown that it takes five years of intensive use of a smartphone to have an equivalent ecological footprint for the use and manufacturing phases (Dufour, 2017). At this point, one question remains: why is the manufacturing phase, involving the extraction of raw materials, so damaging to the environment? The answer lies in the composition of a smartphone. They are mainly "made up of a combination of metals including rare earth elements, glass, and plastic" (Jardim, 2017, p.3). These metals are finite resources, requiring the use of highly polluting fossil fuel-powered machines, and are very difficult to recycle (Ekwateur, 2023). Only some elements

can be recycled, but as a smartphone contains such a wide variety of different components, it is almost impossible to differentiate them to give them a second life (Dufour, 2017). In Appendix 1, you can find a Mendeleyev table showing all the metals contained in a smartphone. Moreover, all the chips present in smartphones are made of silicon wafers, which require a lot of energy and water to be produced (Jardim, 2017). Unfortunately, these environmental issues, including the depletion of the earth's resources, the destruction of ecosystems and the pollution of air, water and soil, are not the only ones caused by the intensive production of smartphones. Many social issues are also at stake. Working conditions in rare-metal mines are disastrous and dangerous for workers, and all for poverty wages. These polluting exploitations can even contribute to the instability of the countries where they are located, of which the Democratic Republic of Congo is the most striking example. Furthermore, safety standards are, in most cases, totally neglected and this leads to accidents, often fatal. Sanitary conditions are also often precarious, with access to very limited quality water, which can cause serious illness among workers (Kroutchinin & Baudrier, 2019). This part, which aims to show the various damages caused by the smartphone industry and that more research is needed in this field, demonstrates that we cannot afford to use the same model of profit first for another 10 years. It is time to change it and use the smartphone industry as an example for all others to embrace the climate change challenge and move towards a better and more sustainable world (Jardim, 2017).

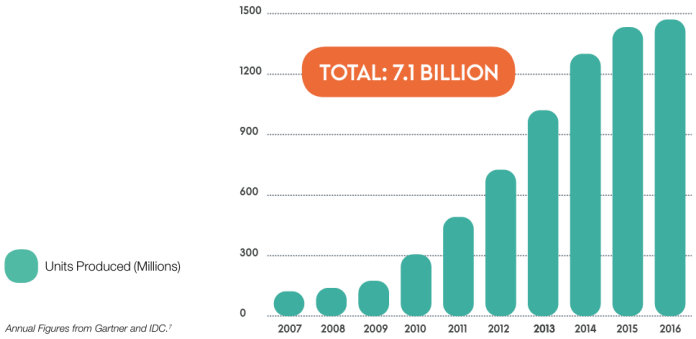

Figure 1: Number of smartphones produced per year (Jardim, 2017).

These concrete actual examples, the increasing environmental concerns about smartphones and therefore the growing need for sustainable changes, but also our interest in participating, on our scale, in the ecological transition, have led us to the following research question: **"What factors influence consumers' repair and replacement propensities in the Belgian smartphone sector?".** In order to tackle it, we, firstly, need to define some concepts as Circular Economy, repairability, replacement, the Right to Repair movement and to briefly present the existing repair regulations.

The **Circular Economy** has gained significant interest, in recent years, in academia and industries (Simon, Adam, Lars & Johan, 2021) and can be defined as a system-based approach that increases product lifetime to achieve global sustainability goals (Terzioğlu, 2021) (Rogers, Deutz, & Ramos, 2021). The increase in the product lifetime is done by enabling repair, reuse,

and maintenance of the product instead of recycling (Terzioğlu, 2021), as recycling requires a new product stage to return the product to a reusable form (McCollough, 2009).

The repair of products plays a crucial role in promoting environmental sustainability as it can reduce the demand and resources for new products (Scott & Weaver, 2014). The concept of **repairability** can be defined as the action of repairing a damaged, worn or faulty product by replacing or fixing parts (Karam, Hussein & Hegner Reinau, 2021) in order to extend its lifespan (Sabbaghi, Esmaelian, Cade, Wiens & Behad, 2016). Hernandez, Miranda, and Goni (2020) have identified four dimensions of repair. The first is the level of repair that needs to be carried out and the second is the person doing the repair. This person can be the consumer himself or a professional repairer. The third dimension includes all the financial, environmental and emotional outcomes of the repair while the fourth focuses on all the factors that can influence consumers' repair decision and is central for our master's thesis.

In contrast to repair concept, **replacement** can be defined as purchasing a new product instead of going through the actions of repairing even though the product is still usable or slightly damaged. Whether repair or replacement, they are influenced by different factors that have been identified in our literature review.

Consumers play a fundamental role in promoting sustainable consumption. The **Right to Repair movement** has emerged to protect individuals' freedom to repair their products and to allow independent third-party entities to repair them (Nicholas, 2020), providing consumers with greater autonomy in the marketplace (Jared A., 2021). The Right to Repair movement, which originated in Massachusetts, aims to promote legislation in EU laws that requires manufacturers to design their products in a repairable way, thereby increasing the lifespan of the product (Fishlock, Thompson & Grewal, 2023).

In 2019, the EU has introduced a new directive called the **"Right to Repair Directive"** (O'Neill, 2021) which empowers consumers to make decisions regarding their broken products. Essentially, this directive encourages manufacturers to create more sustainable products by making them easier to repair (Karam et al., 2021). By doing so, it seeks to lower the barriers that often discourage consumers from repairing their products (Hernandez et al., 2020). In addition to the EU directive, some EU Member States have taken their own initiatives to promote repair practices. For instance, France has developed a reparability index (O'Neill, 2021) while Sweden and Austria which have adopted tax reduction plans in order to reduce the repair cost (Rogers et al., 2021).

Despite the significant willingness to repair, the primary motive for purchasing a new digital product is often due to the malfunctioning of the previous one as there are still factors that discourage final consumers from undertaking repair actions (Laitala, Grimstad Klepp, Haugrønning, Throne-Holst & Strandbakken, 2021). Factors, considered as barriers to repair for consumers, have contributed to an increase in obsolete products, creating environmental and economic concerns (Sabbaghi et al., 2016).

These factors, which influence the final consumer's decision to repair their broken products, have been identified in this master's thesis. After reading several scientific articles, we have identified 19 factors that theoretically influence consumers' decisions between repairing and replacing a product. Based on this, we have created a theoretical framework that groups these 19 factors into four main categories. The first category reflects the factors that are specific to consumers. For instance, we grouped into this category consumer's socio-demographic criteria such as gender, age and level of income. The second category includes one factor that represents the impact of the attractiveness of new products, which only affects the consumer's replacement decision. The third category brings together the factors that influence the cost, the ease and quality of the repair. Lastly, the fourth category affects both consumers' repairing and replacement decision.

The complete methodology that we have established in order to answer our research question is divided into 6 main parts. The first one is precisely the identification of these 19 theoretical factors that we had to reduce to 10 (phase 2) before conducting a quantitative study on Belgian consumers (phase 3). We had to reduce the 19 identified factors to 10 because of the complexity of the model we wanted to build. Phases 4 (visualization of factor priority) and 5 (review of the initial framework) brought us to the sixth phase which is the identification of solutions to increase consumer repair action. Based on the results of our literature review, we kept the factors with the most significant impact on the repair propensity.

The quantitative study was conducted through an online questionnaire following 7-Likert scales which enabled the respondent to give a precise answer on the option that best matches their repair propensity and how the factors influence it. With the 241 valid responses that we had the chance to collect, we were able to perform our quantitative study by using a multiple regression function and Anova 2 tests. The regression analysis has enabled us to identify the factors that have a significant impact on the propensity of consumers to repair smartphones. Anova 2 tests allowed us to identify factors that have a significant difference in their results when we look at the various categories of gender and age among consumers. All this has allowed us to identify five significant factors affecting the propensity to repair of the final consumer which are economic attachment, consumer's age, repair time and efforts, repair services and environmental concerns.

In other words, our contribution through this master's thesis is to make a list of the existing influential factors on consumers' repair decision and to identify which ones are truly significant in order to propose solutions to increase the number of repair decisions taken by consumers. Having a list of numerous factors that influence consumer decision-making between repair and replacement can be seen as a valuable starting point for further research. Furthermore, knowing which factors are truly significant when consumers have to make this decision enables multiple stakeholders to make decisions accordingly. In the last sub-section of the analysis part, we present seven solutions that the different economic actors, such as

companies and states, can use to promote the Circular Economy by increasing the number of repair activities.

Regarding the structure of this master's thesis, the first part, after this introduction, is devoted to the synthesis of what lies in the scientific literature on this subject. In this first part, there are definitions of the main concepts used, a contextualization of what is already in place and the identification and description of a large number of factors that influence the final consumer's repair and replacement propensities. The second part is related to the 6-phases methodology that we have followed to answer our research question. The third and more substantial part of our master's thesis corresponds to the analysis of the results, coming from our quantitative questionnaire, which leads us to review the initial framework and to provide solutions to promote the Circular Economy by increasing the number of repair actions. The final section presents the main findings, as well as limitations and future research needs.

2. Literature Review

This literature review section is divided into five main points. The first is a contextualisation of the subject of repair and the Right to Repair movement, with definitions and explanations. The second point concerns the regulations on repairs that already exist in Europe, of which the best known is the European Right to Repair Directive, which aims to give power and autonomy back to consumers in the repair market (Jared A., 2021). This brings us to the third sub-section, which briefly presents consumer behaviour with regard to repairs. The fourth and most important point describes the 19 factors influencing consumers' decision between repair and replacement that we have identified in the scientific literature. Finally, the fifth sub-section deals with the contributions of this master's thesis to increasing repair activities in order to support the Circular Economy.

2.1 Repair and Right to Repair – Putting things into context

The notion of Circular Economy remains a nascent concept, highlighting the significance of preserving and restoring the value embedded within materials and products (Svensonn-Hoglund et al., 2021). The Circular Economy is a system-based approach to today's economy that offers the opportunity to meet global sustainability goals by retaining value throughout the lifecycle of materials (Terzioğlu, 2021) (Rogers et al., 2021). The main objective of a Circular Economy is to maximize the lifetime of the product by enabling repair, reuse and maintenance instead of recycling (Terzioğlu, 2021). Reusing a product by repairing it is more environmentally friendly than recycling. On the one hand, recycling a product requires a new energy-intensive production stage to return the product to a reusable form (McCollough, 2009). On the other hand, repairing has an important positive impact on environmental sustainability as the demand for new products and the resources associated with it could potentially be reduced (Scott & Weaver, 2014).

The art of repairing objects has become a lost trade within our contemporary economic system (Karam et al., 2021). The concept of repairability can be defined as the action of repairing a damaged, worn, or faulty product by replacing or fixing part(s) (Karam et al., 2021) in order to prolong the lifetime of a product (Sabbaghi et al., 2016). This can be done by consumers themselves or by professional repairers. Hernandez and al. (2020) identify four dimensions of repair. Firstly, the level of repair which "refers to the magnitude and type of repair", ranging from simple maintenance to more advanced repair actions. Secondly, the repair agent, who is the person repairing the product. Thirdly, the repair outcomes, which "refers to the end-results of the repair activity" and can take the form of financial, environmental and emotional benefits. Fourthly, factors that influence repair decisions, which are the focus of this master's thesis and will be explored in depth in sub-section 4 of the literature review.

Svensonn-Hoglund et al. (2021) identify several key stakeholders in the repair market. Firstly, the supply side, which includes all the players who carry out a repair action: original equipment companies, third-party repairers and consumers who repair their items themselves. This relates to the second dimension of repair mentioned above. Secondly, the demand side, which includes all end consumers wishing to repair their defective products. Thirdly, national but also international governments, such as the European Union (EU), who set the rules for the repair market. Finally, there are the earthly limits that cannot be exceeded.

The role of consumers is fundamental in fostering sustainable consumption. According to Jaeger-Erben, Frick & Hipp (2021), electronic devices are often replaced before the end of their technical lifetime, even if they are still usable or could be easily repaired (Jaeger-Erben et al., 2021). The final consumer is accountable for keeping the product or choosing to buy a new one but is independent of how eco-friendly the product is designed (Roskladka et al., 2023). Furthermore, each individual is also responsible for the way in which the Circular Economy loop closes, as they can choose to discard, reuse or repair its products (Terzioğlu, 2021). This is where the promotion of the Right to Repair began. The Right to Repair movement emerged to uphold individuals' autonomy in repairing their products and to ensure that independent third-party entities have the possibility to repair them (Nicholas, 2020) in order to give consumers greater autonomy in the marketplace (Jared A., 2021). Moreover, the initiative to promote the Right to Repair highlights the impact of waste and electronic waste, created by end consumers, on our planet (Roskladka et al., 2023). This movement began in 2012 in Massachusetts, where the first law on the Right to Repair vehicles was issued (Nicholas, 2020). This first regulation was published following the observation that since the Industrial Revolution, our society has gradually forgotten the notion of repair, whereas before it was normal for people to repair their own products (Hatta, 2020).

During our scientific research, we found that timid eco-sensitivity considerations were already present in the 2009 European regulation which aimed to force manufacturers to design products with ecological and environmental factors in mind. New regulations came afterward

to reinforce the EU position on Circular Economy (O'Neill, 2021). These actions taken by the EU do not leave companies indifferent, as a response they are creating strategies to avoid the negative impact of these regulations on the company's economic health. For instance, device makers create parts that can only be disassembled using specific and expensive tools, or they make it difficult for final users and independent repair shops to obtain repair documentation (Perzanowski, 2021). The current debate lies at the intersection of copyright law, corporate financial interest, environmental impact, and fundamental concepts of ownership from a business perspective. This is fuelled by Apple's error 53, which predicts a certain malfunction of the device after the installation of a replacement part (Nicholas, 2020). This error is justified by Apple as a 'security measure'. Another example that fuels this current debate is the EULA[1] contract issued by the John Deere company which mentions that only authorized independent and John Deere garages can work on tractors as they have specific software codes and tools created by the tractor company (Nicholas, 2020). This type of error and contract not only limits the fundamental concept of ownership but also increases the negative impact on the environment. The Environment Protection Agency (EPA) reported in 2015 that Americans from the US have produced 3 100 000 tons of e-waste (Nicholas, 2020).

There is significant opposition from interest groups, as illustrated by the examples of Apple and John Deere, which underlines the importance of regulating the repair industry. Opposition can take different forms to defend the financial interests of companies. The widespread use of digital technologies has enabled companies to create increasingly complex software, making repair difficult. The example above on error 53 from Apple is a good demonstration of these technological advances. Furthermore, with this kind of code embedded in software, companies have been able to develop various form of planned obsolescence to shorten product life cycles. Opposition to the movement can also be seen in trade-in programs, where consumers are offered a monetary reduction on a new product in exchange for their old ones. Related to Perzanowski (2021), trade-in programs are a good strategy for controlling second-hand markets as the company is able to control it by taking back goods and then prevent end-consumers from driving down demand and prices for new products. These two techniques, which characterize part of the opposition movement, are just two of many. Their sole purpose is to slow down consumers' ability to repair their products. Federal authorities are feeling the pressure to acknowledge these challenges and implement regulations that prioritize consumer access to product repairs (Perzanowski, 2021). Right to Repair movement is a drive for legislation, especially EU laws that aim to promote the repairable design of products in order to increase its lifespan (Fishlock, Thompson & Grewal, 2023).

2.2 Existing repair regulations in Europe

As our research is based in Belgium, we only describe legislation introduced by the EU or by members of this political and economic union. Until recently, regulations on repairs were

[1] End User License Agreement

mainly aimed at producers (Hernandez et al., 2020). However, in October 2019, the EU launched a new directive, which may change this trend. It is called the "Right to Repair Directive" and is part of the European Green Deal, which aims to be climate neutral by 2050 (O'Neill, 2021). This new regulation is not the first directive to enhance sustainability. It comes on top of the Eco-design Directive, whose objective is to "compel manufacturers of energy-using products to design them with ecological and environmental considerations in mind, such as reducing the pollutions created in the production process and increasing recyclability" (O'Neill, 2021, p. 1).

The EU Right to Repair Directive targets consumers by giving them the means to decide what they want to do with their broken products. The main objectives of this directive are to encourage manufacturers to build more sustainable products (Karam et al., 2021) by increasing the reparability of certain energy-consuming products, and therefore to reduce certain barriers that discourage consumers from repairing their products (Hernandez et al., 2020). The regulation applies to four types of products: refrigerators, dishwashers, washing machines and monitors, and places a number of requirements on manufacturers, of which the following are the most important. Firstly, spare parts must be available for seven or ten years, depending on the product, after the last unit enters the EU market (O'Neill, 2021). These spare parts must be in the hands of private individuals or third-party repairers within 15 working days. Secondly, companies must supply spare parts that can be replaced by common tools that everyone is likely to have available easily. Thirdly, companies must design their products in such a way that they can be easily disassembled by private individuals or third-party repairers. Finally, independent professional repairers must have access to relevant information on product repair (Jared A., 2021).

In addition to EU directives, some EU Member States have taken their initiatives to improve repair practices. Firstly, France has launched a reparability index, which is "a score out of ten that manufacturers must add to the labels of washing machines, laptops, smartphones, televisions and lawnmowers" (O'Neill, 2021, p. 1). This rating includes several criteria, such as disassembly of goods, provision of useful information, and spare parts for repairs. The aim of this initiative is to increase information on the repairability of products, thereby enabling consumers to make more informed decisions and giving manufacturers more incentive to produce repairable products (O'Neill, 2021). Secondly, Sweden and Austria have adopted tax reduction plans. In Sweden, repair costs are 50% tax-deductible, and in Austria, these same costs are reimbursed at a rate of 50% up to a limit of €600 per year (Rogers et al., 2021).

Although all these national and European regulations on increasing repair practices are positive, the European directive on the Right to Repair has two major limitations. Firstly, it only concerns certain products and should be extended to a wider range of goods in the coming years. Secondly, and most importantly, manufacturers retain ownership of spare parts, which allows them to control prices on the market. If they decide to set a high price, even though spare parts are available, consumers will not decide to repair them. These limitations have prompted the EU to extend, in the future, the products included in the

legislation to mobile phones, tablets, and laptops (O'Neill, 2021). In addition, France's reparability index inspired the EU to introduce "a displayable repair score to indicate the reparability of products in an understandable way for consumers" (Svensonn-Hoglund et al., 2021, p. 9). However, repair regulations are not easy to put in place because the concept of repairability is multidimensional which "means that any directive or law promoting repairability should have a wide vision of the concept considering all the actors and dimensions involved" (Hernandez et al., 2020, p. 12).

The EU Right to Repair Directive has the power to give back to the final consumer the right to do what they want with their broken products as their behaviour is influenced by the position of the government (Rogers et al., 2021). The results of such regulations may influence consumers by increasing the promotion of taking care of product (Hernandez et al., 2020), and influence consumer behaviour by lowering effective barriers to repair (Perzanowski, 2021).

2.3 Consumers' (repair) behaviour

According to a recent Eurobarometer survey, the primary motive for purchasing a new digital device is due to the malfunctioning of the previous one. This suggests that repairing these products could significantly extend their usage period and emphasizes that the ultimate decision to prolong the lifespan of the product lies with the end consumer. Moreover, according to this same recent survey, a significant number of individuals (77%) are willing to take actions to repair broken appliances instead of purchasing new ones, with the aim of reducing household waste (Laitala et al., 2021). Additionally, the Behavioural Study on Consumer Engagement in the Circular Economy of the European Commission shows that "on average more than half of consumers (median of country-level results = 54%) reported that they take the environmental impact of goods and services into account when making a purchasing choice" (Cerulli-Harms et al., 2018, p. 48). Figure 2 shows that Belgium is above the median, with a value of over 60%, putting it in sixth place. In addition, a behavioural study on consumers' willingness to engage in the Circular Economy, conducted by the European Commission, revealed that 64% have already opted for repair services (Cerulli-Harms et al., 2018). Furthermore, a study conducted by Laitala et al. (2021) suggest that repair rates are likely to differ among various consumer groups, product types, and repair personnel.

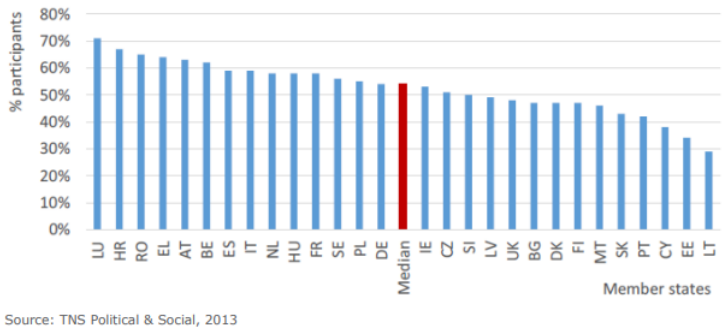

Figure 2: Consumer attitudes towards the environmental impact of products (Cerulli-Harms et al., 2018)

According to Fogg's behaviour model, presented by Ackermann, Mugge and Schoormans (2018), each behaviour is primarily influenced by three factors: motivation, ability, and triggers. Motivation refers to a person's willingness to take action, which can be positively impacted by pleasure, hope, or social acceptance, but negatively impacted by pain, fear, or social rejection. Ability refers to the capacity to the person to do the action and takes into account factors such as time, money, physical effort, social deviance, and non-routine. Finally, triggers are the stimuli that push people to perform a behaviour. There are three types of triggers that are linked to the first two factors: spark triggers that increase motivation that could be a positive feeling after acting in favour of the environment by repairing your broken smartphone, facilitator triggers that improve ability, and signal triggers that serve as reminders for those who are already motivated and have the ability. The desire for social acceptance and avoidance of rejection can significantly impact individuals' daily actions. It can serve as a motivation or act as a barrier. Ackermann et al. (2018) have found that taking care of products is a socially acceptable behaviour. Additionally, people tend to prefer familiar tasks, making non-routine actions more challenging. If product maintenance requires a high level of skill, this latter can be seen as a barrier to upkeep.

According to Fogg's behaviour model of Ackermann et al. (2018), the presence of both motivation and ability is required to prompt action. Figure 3 shows that in the absence of one or both of these factors, triggers will be ineffective, and no action will be taken. Conversely, high levels of motivation and ability can offset each other. For example, if motivation is particularly strong, people will try to adopt a behaviour when they are prompted to do so by a trigger.

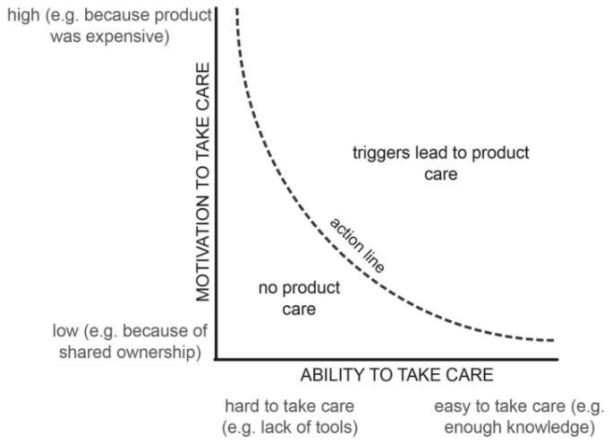

Figure 3: Specified Fogg's model based on the uncovered factors of motivation, ability and triggers for product care (Ackermann et al., 2018).

Despite the growing public interest in repairing broken products, as reported by the Eurobarometer, there are still factors that discourage consumers from doing so. These barriers have contributed to an increase in obsolete products, posing both environmental and economic concerns. One of the primary reasons cited by individuals for avoiding repairs is the high cost (Sabbaghi et al., 2016). In addition, our research has identified several factors that influence end-consumers' decision to carry out repair activities.

2.4 Theoretical factors influencing consumers' repair decisions

This sub-section defines the 19 factors identified in the scientific literature that influence consumers' decision between repair and replacement, all listed in Appendix 2.

To get a clearer picture of these factors and their influence on consumer choice between repair and replacement, we have decided to create a theoretical framework that groups them into four main categories, numbered from I to IV. Each category affects the choice between repair and replacement in different way. The first category contains five different consumer-specific factors. We decided to include poor corporate behaviour in this first category, as we consider that organizations have a non-negligible influence on consumers themselves and therefore on their choices. The second category affects only the replacement dimension of consumers' final decision between repair and replacement. The third category is the opposite of the second, in the sense that these factors affect exclusively the repair side of the consumer's choice. The fourth and final category, which affects both sides of this same decision, concerns the differences between products. You can see this theoretical framework, which will serve as the basis for our analysis, in Figure 4.

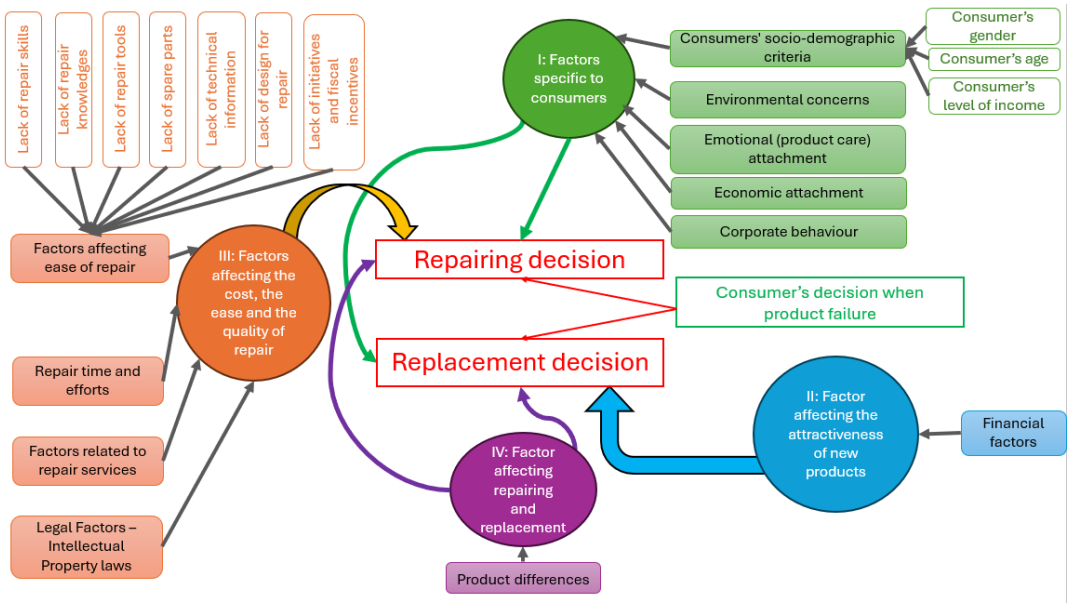

Figure 4: Theoretical framework about the factors influencing consumers' decision between repairing and replacement.

I: Factors specific to consumers

(A) Consumer's gender

The consumer's gender, age and income level can be grouped together as socio-demographic criteria that influence their propensity to repair. According to Laitala et al. (2021), men and women have the same likelihood of repairing.

(B) Consumer's age

According to a European study (Cerulli-Harms et al., 2018) and Lefebvre et al. (2018), the age of the consumer has a notable influence on the number of repairs they will carry out. Indeed, older people are more inclined to carry out repairs.

(C) Consumer's level of income

In terms of consumers' financial situation, people with low incomes are more prone to repair than people with higher wages. This can be explained by their desire to minimise their expenses by maximising the lifespan of products (Sonego et al., 2022) and by the fact that a higher income often encourages individuals to buy new (expensive) products rather than take the time to repair them (McCollough, 2019).

(D) Environmental concerns

Environmental concerns refer to the fact that individuals are aware of the damage caused to the environment by the abusive and unnecessary replacement of products rather than repairing them (Terzioğlu, 2021). Pro-environmental consumers therefore want to reduce their impact on the environment by preferring repair to replacement (Terzioğlu et al., 2015). It is often acknowledged that this type of person has a greater propensity to repair than others (Lefebvre et al., 2018) because they are pleased to reduce their environmental footprint by repairing.

(E) Emotional (product care) attachment

In an increasingly competitive economy, it is becoming complicated for consumers to make a differentiation between products with similar qualities and prices. Therefore, the emotional aspect of attachment plays an important role in consumer decisions, as it is their emotions that will lead them to make a choice on the basis of a characteristic or artefact that a product possesses (Maclachlan, Harrison & Wood, 2009). The emotional side that the consumer may have towards a product can be decisional. According to our literature research, products with strong temporal identities can become obsolete very quickly due to their design and the emotions that they provoke in people (Hernandez et al., 2020). Emotional attachment refers to a product that has been used for a long time and is highly valued by consumers, but also to when, how, and where that product comes from. It is an important factor as it can change the way users view repairing activities (Terzioğlu et al., 2015).

Another dimension can be added to this factor is product care. In the literature, we have found results linking product care and emotional attachment through irreplaceability. Product care is defined by Ackermann et al. (2018) as the search for product improvement, through the purchase of suitable accessories and protective parts to keep the product in good condition as well as generally careful and thoughtful handling. In their study on product care, the authors found that irreplaceability is a factor that has a positive influence on consumer motivation. Irreplaceability means that consumers are affectively attached to the product (Ackermann et al., 2018) and is therefore clearly linked to emotional attachment.

(F) Economic attachment

The lack of economic attachment is also considered a major barrier to repair due to its important role in repairing activities. In the scientific literature, it refers to the level of attachment that consumers have to their products but from an economic point of view. Hernandez et al. (2020) state that economic attachment includes the importance of the initial

investment in the value of the product. Repair activities will be more frequent if the initial price of the product is very high.

These two attachments to the product, emotional and economic, are correlated with the willingness to repair (Lefebvre et al., 2018).

(G) Corporate behaviour

Factors specific to consumers can also find their origin in corporate behaviour in the sense that they greatly influence their choices, and the question of repair as compared to replacement is no exception. We have identified eight different types: planned obsolescence, marketing strategies based on over-consumption, conspicuous consumption created by companies through a culture of anti-repair, the creation of a throwaway consumer society and access to a large number of new products, consumer manipulation by companies, big tech companies concerns about cybersecurity and data privacy, the offer of poor or no warranty services on repairs and volume and profit targets.

Planned obsolescence is a corporate strategy in which a product is deliberately designed to limit its lifespan while restricting access to maintenance and repair (Hernandez et al., 2020). This must be seen as a marketing strategy for encouraging the consumer to replace an old model with a new one by making items difficult to repair, not providing information, making parts incompatible with other models, and finally by frequently bringing new products to market in order to create psychological obsolescence (Hatta, 2020). According to Jaeger-Erben et al. (2021), psychological obsolescence is often used to cover cases where human thinking and acting shorten lifespan and, therefore, a product that still performs well can seem outdated due to changes in style or other factors. Consumers are demotivated if they know that repairing is just pushing back the product's lifespan a little further as they know that manufacturers have planned for other product components to break after a certain time (Terzioğlu, 2021). Companies see planned obsolescence as an obligation to technical progress, which in turn encourages innovation and the creation of new products which increase in the same way the complexity of the product.

An increase in advertising from marketing strategies will influence consumers to choose the replacement option more than the repair alternative. One of the main objectives of advertisers is to encourage consumers to replace old models by informing them of the latest technologies, features and designs incorporated in new models (McCollough, 2009). Many marketing and communication strategies aim to increase sales of new products and are designed to drive over-consumption (Lefebvre et al., 2018). They do this by offering new features to shorten the product life cycle, so that consumers buy new products on their own after a very short period (Perzanowski, 2021).

Conspicuous consumption is a type of consumption in which:

> Consumers will elect to replace an old malfunctioning household product with a new replacement product despite the fact that repairing the older product would serve the

> same purpose and be a cost saving… [because] consumer wants to show off their economic standing and achievement in society (McCollough, 2019, p. 36).

This type of consumption has a considerable negative impact on natural resources and can lead to a number of long-term problems (McCollough, 2019). Companies play a decisive role in the creation of conspicuous consumption, by creating a culture against repair by making it difficult (Jared A., 2021), and therefore by increasing the current throwaway society (Svensonn-Hoglund et al., 2021). A culture against repair is problematic because Circular Economy practices are not rewarded by society (Cerulli-Harms et al., 2018) and, even more, repairing products is perceived as economic poverty (Terzioğlu, 2021) or an inability to maintain products with care (Rogers et al., 2021). Today's disposable society emanates from companies' creation of an anti-repair culture and is a determining factor that increases the replacement option (Svensonn-Hoglund et al., 2021). The ease of access to a large number of new products offered by companies is also determining in increasing conspicuous consumption (Pérez-Belis et al., 2017). Companies produce a large number of new products every year, and these are more readily available with the use of online shopping (Jaeger-Erben et al., 2021). In addition, most consumers feel that new products have a better monetary value than repaired products (Cerulli-Harms et al., 2018). The propensity to repair declines considerably due to the widespread availability of new products.

It is nothing new that large companies sometimes manipulate consumers, and repair activities are no exception to the rule. Some companies give consumers the opportunity to return their old products, which in the vast majority of cases will simply be discarded, in exchange for a reduction in the price of new products in their catalogue (Perzanowski, 2021). This strategy gives companies greater control over the market as consumers are influenced because they will consider the option of replacement earlier than they would without the discount offered by the company. In addition, the major manufacturers "have been accused of systematically inflating repair prices" (Svensonn-Hoglund et al., 2021, p. 6).

The repair movement is facing resistance from major technology companies who are concerned about cybersecurity and data confidentiality, for two main reasons. The first is that independent repairers have access to the whole product and all the information they contain during the repair service. Secondly, an untrained independent technician can, during the repair, "disable hardware security technology and make devices vulnerable to hacking or other malware" (Jared A., 2021, p. 394) and, as a result, compromise the product's entire security system. However, there is little evidence regarding the cybersecurity and data privacy issues that repair actions may cause for consumers (Jared A., 2021).

Warranty services offered by businesses have a different effect depending on what they include. On the one hand, if the warranty does not include repair, users will prefer the replacement option (Laitala et al., 2021). If the product is broken and the repair does not fall within the scope of the warranty or within the post-purchase warranty period, the final consumer will tend to replace when he perceives the cost of repair to be bigger than

replacement (Lefebvre et al., 2018) based on cost-value consideration (Laitala et al., 2021). On the other hand, if the warranty includes repair activities, individuals will be more inclined to repair their products (Terzioğlu et al., 2015). According to Lefebvre et al. (2018), warranties encourage replacements. The boundary between repair and replacement is dictated by OEMs[2]. The decision is generally based on a number of cost factors when the company is facing to the decision of repair or replacement. These factors are the age of the product, the number of times it has been repaired, the availability and storage of spare parts, the tools required, and the cost of skilled labour. These factors are most often part of complex algorithms that the company sets up according to its various repair requests. For instance, if the expected costs of repairing are bigger than 50% of the product's original value, companies prefer to replace it (Svensonn-Hoglund et al., 2021). Moreover, consumers are also influenced by the lack of legal warranty transparency. For example, warranty stickers on products have been demonstrated to increase the fear of violating warranty conditions by carrying out repairs on our own (Terzioğlu, 2021). This lack of transparency also incorporates an additional financial cost. As mentioned in the sub-section on *Repair and Right to repair – Putting things into context*, the EULA contact between John Deere and its customers obliges farmers to call a John Deere certified mechanic to diagnose a repair or repair the tractor. The process is time-consuming and costly for farmers, who would be able to carry out repairs themselves that require little mechanical skill, but they need to break the digital lock software and infringe the AULA contract. By proceeding in this way, farmers avoid the warranty on their equipment, which is often very expensive (Jared A., 2021). Consumers have a lack of knowledge about their legal rights to repair and about how their product works, which in turn influences their ability to judge the repairability of the product (Svensonn-Hoglund et al., 2021).

Volume, product sales and profit drive most large company business models and this increases the number of replacement purchases (Svensonn-Hoglund et al., 2021). Many business leaders believe that a longer product life would inevitably reduce sales and therefore profits (van Nes & Cramer, 2005). These economic incentives are one of the main reasons why sustainable design strategies are not applied (Simon et al., 2021).

II: Factors affecting the attractiveness of new products

(H) Financial factors

The financial factors include the overall price of repair alone, but above all the ratio between this price and the price of replacing a product. Unfortunately, this ratio is not moving in the direction of an increase in repairs due to the presence of cheap (and low-quality) products.

The cost of repair is recognised as one of the biggest, if not the biggest, barrier to repair, and the smartphone industry is no exception (Jaeger-Erben et al., 2021). Expensive replacement parts and tools, as well as costly out-of-warranty labour, are factors that increase the cost of repair (Sabbaghi et al., 2016), which obviously reduces the propensity to repair for consumers.

[2] Original Equipment Manufacturers

The financial cost of repair is already in itself a barrier to consumer repair activity, but the ratio between the cost of repair and the cost of product replacement is even more important (Cerulli-Harms et al., 2018). The smaller the difference between these two costs, the more consumers will decide to buy a new product (Perzanowski, 2021). In other words, when the cost of replacement is lower or the same than the cost of repair, consumers feel that the product is even more obsolete and that they are justified in replacing it (Lefebvre et al., 2018). In recent decades, the price of replacement products has fallen considerably thanks to several factors: "new production methods, new production technology, outsourcing of manufacturing, reduction of trade barriers, increased efficiency in transportation and other efficiency improvements" (McCollough, 2019, p. 34). By contrast, the price of repair has risen as economies have progressed, particularly in advanced markets, due to higher workforce costs (Sonego et al., 2022). “The dynamics of ever-decreasing replacement prices along with ever-increasing repair prices further magnifies the ratio of repair price to the replacement price, thus intensifying the reduction in demand for repair services” (McCollough, 2009, p. 624).

The massive presence of new cheap (and low quality) products strongly influences this ratio in favour of the replacement choice. Low replacement costs give the impression that products are easy to replace (Svensonn-Hoglund et al., 2021). Therefore, cheap products are an important factor in reducing the individual's willingness to carry out repairs (Laitala et al., 2021).

III: Factors affecting the cost, the ease and the quality of repair

(I) Repair time and efforts

Repairing can take time and efforts. This factor is one of the most important according to the scientific literature. It is defined as "the amount of time and effort required to complete the repair" (Terzioğlu, 2021, p. 6), which includes searching and waiting for a repair (Roskladka et al., 2023).

The influence of time and efforts required is very clear on the propensity to repair of consumers. The more time and efforts required to carry out the entire repair activity, the more likely consumers will replace their defective products (McQueen, Jain, McNeill & Kozlowski, 2023). We can even go further and say that if repairing an item takes a slightly longer time than replacing it, many people will choose the replacement option (Cerulli-Harms et al., 2018). Unfortunately, in today's society, people are really limited by time (Ackermann et al., 2018), as work is a bigger part of most people's lives than in the past. Furthermore, the vast majority of the time left over after work is dedicated to other purposes than repair, but rather to leisure activities. In other words, the factors associated with time and efforts are stronger when more hours are devoted to professional activities (McCollough, 2019).

(J) Lack of repair skills

The lack of repair skills is an influencing factor that discourages consumers from conducting repair activities (Lefebvre et al., 2018). It "refers to the ability to carry out a repair task with a

determined result involving cognitive skills to develop ideas and technical skills" (Terzioğlu, 2021, p. 6). Repair actions can be associated with different skill levels, from assembly repair, which has no skill requirements, to advanced repair, which demands advanced technical skills, via medium-level repair, which requires intermediate skills (Terzioğlu et al., 2015). Sometimes people really do not have the skills required to carry out a repair action, but in some cases, this is simply a belief because they perceive repair as an impossible task (Ackermann et al., 2018). In this case, it is more a lack of knowledge about repairing than a real lack of skills that can be seen as a barrier.

(K) Lack of repair knowledge

Choosing the replacement option rather than repairing can be based on insufficient pieces of knowledge about repairing. This takes different forms: lack of knowledge on how the product and repair work and therefore thinking that it is irreparable (Lefebvre et al., 2018), but also more generally from a lack of information about sustainability or their legal rights to repair. By missing these kinds of information, companies that build products with a long lifetime and which are easily repairable are not recognised by individuals (Cerulli-Harms et al., 2018).

Lack of knowledge about how products work is a barrier to repairability, especially "with the explosion of electronics and new technologies in the market" (Hernandez et al., 2020, p. 5). This factor "refers to the lack of knowledge that is required to repair the product, also the lack of knowledge about where to get the necessary materials, tools, and how to use them" (Terzioğlu, 2021, p. 6), but also about where to find a repair service (Terzioğlu et al., 2015). Lack of product knowledge is problematic because it reduces a consumer's ability to assess the repairability of an object when it is broken or when buying a new product (Svensonn-Hoglund et al., 2021). In addition, individuals believe more strongly that the good is simply irreparable (Roskladka et al., 2023).

More broadly than a lack of product knowledge, the failure to consider the repair option may arise from a lack of information about durability and sustainability. This obstacle leads to a lack of awareness of the negative impact of replacement compared with the repair of the product (Roskladka et al., 2023). Fishlock et al., (2023) have identified the lack of repair education as a cause of this situation, and in particular the lack of appropriate new courses to teach sustainability to university students. One of the consequences of the lack of knowledge about sustainability is the mismatch between different product lifetimes. Consumers buy a product that they think will only last three years, for example, when it is environmentally preferable to keep it for at least five years. Therefore, lifespans differ from the perspective of the user and resource efficiency, but also from the manufacturer's point of view, who in many cases wants to have the shortest lifetime possible in order to increase sales (Simon et al., 2021).

Furthermore, some consumers have no idea or are very confused about their repair rights and therefore can make wrong choices where repair and replacement are envisaged. For example, the legal guarantee provided by consumer law can easily be confused with

commercial guarantees offered by companies. This is exacerbated by the lack of clarification on warranty rights (Svensonn-Hoglund et al., 2021).

(L) Lack of repair tools

The lack of non-standard tools for fixing any good has been identified as a factor that discourages people from repairing (Lefebvre et al., 2018). Unfortunately, the tools needed to repair highly specialised products are often controlled by manufacturers who restrict access to them. Their strategy is to limit the availability of the tools needed to repair their products in order to encourage people to buy a new product. This strategy has several consequences: individuals and independent repairers have difficulty in finding the right tool to repair or identifying the failure of a specific product (Perzanowski, 2021), but it also makes "warranty services offered by retailers more appealing than repair" (Lefebvre et al., 2018, p. 2042). All these consequences make, in consumers' minds, replacement a more viable option than repair.

(M)Lack of spare parts

Van der Velden reports that "in 46% of cases, repair is not possible due to the unavailability of replacement parts" (cited in Roskladka et al., 2023, p. 7-8), showing the importance of the lack of spare parts as a factor influencing repair decision. Although the availability of spare parts throughout the entire life of products is necessary to enable repair, once again manufacturers play a predominant role in their poor accessibility. Prior to the adoption of the European Right to Repair Directive, manufacturers were the only ones to decide on the number of spare parts they would produce to enable their products to be repaired. The decision to introduce a 'forced' shortage of spare parts could have a negative influence on consumers' perception of repairs carried out by third-party repairers or by consumers themselves. Indeed, to compensate for the unavailability of spare parts, they will use non-original or used parts, which may reduce the quality of the repair and, therefore, consumers' perception that the repair was not the right option (Sonego et al., 2022). In addition, companies have little incentive to make spare parts readily available to independent repairers who will make money in their place (Hernandez et al., 2020).

(N) Lack of technical information

The lack of useful technical information, such as repair manuals, has been identified as a major barrier to repair (Pérez-Belis, Braulio-Gonzalo, Juan & Bovea, 2017). This factor is defined as the "lack of clear and useful technical information, understandable engineering definitions, and diagrams of how to service and repair products" (Roskladka et al., 2023, p. 8). Similar to the last two factors explained, companies play a significant role. As with spare parts, before the European regulation on the Right to Repair came into force, manufacturers were not obliged to provide technical information on some products to repair them easily (Hernandez et al., 2020). Access to this type of useful information would lead to more responsible purchasing decisions and greater care given to the product, as individuals would have better knowledge of the product, and more specifically of its possible sources of failure, and how to act to increase its lifespan (Sonego et al., 2022).

(O) Lack of design for repair

Lack of design refers to bad design and manufacturing processes driven by minimizing the costs leading to a product that is the opposite of a product intended to be repaired. For instance, using glue attachment or welding which are one of the most prominent design related problems (Terzioğlu et al., 2015). Another examples are parts that break when opened and products that require special tools (Hernandez et al., 2020). If the company is not integrating the design dimension of the product by having the environmental and social aspects in mind, the repairability dimension will never be considered in the product's production process (Hernandez et al., 2020). Design for repair according to Huang, Esmaeilian and Behdad (2016) "refers to a set of design efforts to facilitate fixing devices by final consumers and repair shops during the initial product's life cycle" (cited in Hernandez et al., 2020, p. 4).

Another aspect of the lack of design is related to obsolescence, as already discussed above. The designer was intentionally creating planned obsolescence by guaranteeing that the product would look old-fashioned after a short period of time. Companies design a product that meets their requirements in terms of programmed obsolescence, such as using low-quality materials that result in low durability. Planned obsolescence also refers to digital design including software compatible only with new products but also by creating a design including custom parts, glue or quick-fit parts (Svensonn-Hoglund et al., 2021). As we will see in the paragraph below, the adoption of digital technologies allows companies to integrate more sophisticated software codes that restrain the repair activities of consumers and third-party repairers (Perzanowski, 2021). Designing for limited repair and short lifespan leads to an increase in future demand and renew purchases of the product (Sabbaghi et al., 2016). However, according to Hatta (2020), obsolescence is better for society than having products with long life cycles and retains the technical progress brought about by innovation.

Another poor design process is explained by Roskladka et al. (2023) which state that the lack of design also refers to the difficulty in diagnosing failure, the non-modularity, the complexity of dis/re-assembly, the digital locks, the impossibility to upgrade and the unopenability of the product. All this leads to functional obsolescence of the product. Difficult access to diagnostic failures refers to the difficulty of identifying where the error comes from. This trouble in the identification of failures is mainly due to the software systems that do not let the user see the technical product characteristics (Roskladka et al., 2023). Firms try to control access to the identification of the error to consumers and independent repair shops (Perzanowski, 2021). The difficulty of identifying failures is an obstacle because it does not provide information on the cause of the problem (Magnier, Mugge & van den Berge, 2022). Then, the consumer cannot use this information to identify the steps that need to be taken for repair (Magnier et al., 2022).

Designing the product as a monobloc where products are not accessible or undetachable is the non-modularity. A product that contains many parts with very different shapes tends to increase the complexity and the time to dis/re-assembly. In addition, companies often

manufacture products that are impossible to open without damaging or breaking them, which also enhances the complexity of dis/re-assembly (Roskladka et al., 2023). Moreover, there is the fragility of the materials that compose a product that make them less robust (Perzanowski, 2021). This is generally the cause of a low-quality product, which is an important factor influencing consumers' propensity to repair (Lefebvre et al., 2018). In fact, a low-quality product has a greater chance of being replaced than a high-quality product (Sonego et al., 2022).

Digital locks are also widely used by companies, and this consists of selling the device but providing license-based software that does not give ownership rights to the consumer (Roskladka et al., 2023) nor to third parties repairers. This is called “software doping” which can impede the operability of the device by an independent repairer (Svensonn-Hoglund et al., 2021). The last method, used for poor design, is to make a product with an impossibility of upgrading in order to prevent consumers from using the latest upgrade to their product (Roskladka et al., 2023).

During his internship, one of us was confronted to a concrete example of poor design made by companies that render repair actions less credible. Indeed, since iPhone X, Apple has decided to make life more difficult for independent repairers by introducing a warning message when a non-genuine replacement part has been used to repair the smartphone. In other words, when an unofficial Apple repairer replaces the battery, screen or camera with non-genuine, but fully functional parts, a warning message stating "Non-original parts" will appear on the smartphone's screen when it is switched on. Even if this message can be removed later, it could turn customers away from the repair solution, as they are afraid of it. During the internship, several customers brought back their repaired smartphone to buy a new one because their own was displaying this warning message. An example of a dissatisfied client can be found in Appendix 3. To limit the number of unhappy consumers, the company, where one of us completed his internship, places a small carton in the smartphone's box. They are explaining that the smartphone may contain new but non-genuine components, and that these will not affect the device's performance or the scope of the warranty (see Appendix 4). Fortunately, this measure has reduced the number of smartphones rejected by consumers. In addition, this start-up, called aSmartWorld, is trying to eliminate this warning message by using specific repair techniques that take much more time and therefore reduce their profitability. This example, among others illustrates, that poor repair designs by manufacturers put independent repairers in a difficult position and make their work much harder, ultimately driving consumers to choose the replacement option. This example is related to the Apple error 53 explained before.

(P) Lack of initiatives and fiscal incentives

The lack of initiatives and tax incentives to promote repair practices, such as tax deductions or exemptions, is a barrier to repair practices (Roskladka et al., 2023), especially considering the ratio of repair cost to replacement cost explained above.

(Q) Factors related to repair services

Factors influencing consumers' repair decision can also arise from the repair service itself and take different forms: lack of repair services, insufficient quality of repair services, lack of confidence in repair services and fear of further failures due to previous poor repair experience.

The lack of repair services, from companies or independent third parties, is a recognised cause of non-repair. This can lead to a situation where consumers do not know where to find repair shops and therefore replace their broken product (Lefebvre et al., 2018). The unpredictability of the quality of repair services reduces consumers' willingness to carry out a repair (Sonego et al., 2022). The poor quality of repair services may be due to the limited availability of competent staff in the repair sector (Laitala et al., 2021) and repair restrictions imposed by companies on third-party repairers (Roskladka et al., 2023). A European survey indicates that 20% of European consumers reported that the quality of repairs was below their initial expectations (Laitala et al., 2021).

This low quality of repair services can lead to a general lack of confidence in repair service suppliers. This mistrust can stem from a feeling of a lack of transparency in the pricing of repairs which can lead to a feeling of overcharging for the service (Lefebvre et al., 2018), from a feeling that unnecessary services have been provided or from thinking that the repair provider has charged for a service that was never carried out (McCollough, 2009). Another factor that reduces trust in repair services is the failed repair attempts and therefore the fear of further failures (Roskladka et al., 2023). Consumers' past experience with repairs strongly influences their future behaviour. If this experience is negative (high cost, long waiting time, poor quality, etc.), people may be more inclined to choose the replacement option as the most viable (Sonego et al., 2022).

(R) Legal factors – Intellectual Property laws

Some factors may come from the laws themselves. This is the case with Intellectual Property laws, which can reduce the possibilities of reparation for end consumers. These can take the form of company patents, copyright or trademarks.

Company patents prevent private individuals or independent repairers from repairing essential parts, because producers benefit from the exclusive right to manufacture patented parts (Perzanowski, 2021). In the EU, it is much more complicated because there is a lack of harmonization on national patents between Member States. As far as copyright law is concerned, certain clauses prohibit any repair if non-original (company) parts are used. Furthermore, the distribution of information on repairs protected by copyright is banned. Finally, with regard to Intellectual Property laws, the sale or import of refurbished spare parts bearing a registered trademark is strictly forbidden, even though it is common for repair products to incorporate a combination of original and non-original components. Independent repairers are therefore very careful when it comes to using reconditioned parts (Svensonn-Hoglund et al., 2021).

IV: Factor affecting repairing and replacement

(S) Product differences

Consumers do not have the same considerations to repair all products because of their differences. These might stem from their quality, function, age at the time of repair and the number of repairs already carried out.

In fact, there is a tendency to repair more high-quality products than low-quality ones (Sonego, Echeveste & Debarba, 2022). In addition, consumers consider products to be more disposable than others, and this is based, among other things, on their social lifespan. This is why smartphones are more likely to be thrown away than freezers (Laitala et al., 2021). In addition, the age of the product owned is a determining factor in predicting repair actions. The items most likely to be replaced are older and very recent products that are broken and do not meet expectations (Lefebvre, Lofthouse & Wilson, 2018). The number of times the faulty good has already been repaired is also a determining factor in considering a replacement. The more times a product has already been fixed, the less likely it is to be repaired again (Svensonn-Hoglund et al., 2021).

2.5 Our contributions to increase repairing activities

In addition to answering our research question, a second main objective of our master's thesis is to provide other perspectives on the different factors in order to contribute further to research on increasing repair activities. To do this, we relied on a recent study by Roskladka, Jaegler and Miragliotta (2023) entitled "From "Right to Repair" to "willingness to repair": Exploring consumer's perspective to product lifecycle extension". They identified 26 barriers to washing machine repair and tested them through quantitative analysis with experts in this field. Based on this, we wanted to carry out our own quantitative research, rather different, on another object, namely the smartphone. We also wanted to perform it in Belgium, a region where there are very few studies on repair, because of the small market that this country represents. In addition, we wanted to focus our research on conducting a quantitative analysis on consumers rather than experts, in order to analyse which factors they really consider as influencing their decision between repair and replacement. Furthermore, we would like to go further and complete the list of factors influencing consumers' repair propensity, by including, different consumer profiles linked to socio-demographic criteria. This would give us an overview of a great number of the influencing factors to repair that might exist. Finally, we did not just want to draw up a list of these factors for consumers in the Belgian mobile telephony sector, but we wanted to make a real contribution by providing solutions to the most critical ones coming from the results of our quantitative survey. In other words, our main objective is to highlight existing solutions, find new ones in order to increase consumer awareness and repair behaviour, and thus overcome the barriers that stand in their way, and all this with the ultimate aim of promoting the Circular Economy.

3. Methodology

3.1 6-phases methodology

To answer our research question: **"What factors influence consumers' repair and replacement propensities, in the Belgian smartphone sector?"** we have developed a 6-phases methodology that we will describe in this section. A graph summarizing our methodology can be found in Appendix 5.

It should be noted that we will focus our methodology and the following analysis on the consumer's repair propensity, as it is strongly correlated with the replacement propensity. Indeed, if an individual's propensity to repair increases, his inclination to replace will decrease, and vice versa.

(1) Phase 1: Identifying factors influencing consumers' repair decision through a literature review

This phase was carried out in the previous section and produced a theoretical framework presenting 19 factors influencing consumers' decision between repair and replacement.

(2) Phase 2: Selecting the 10 most important factors

The aim of this second phase is to reduce the number of factors to be analysed, by selecting those that are theoretically most important to consumers. This phase was advised by Professor Gordy, a specialist in quantitative analysis at UCLouvain, during a call with him, to get an external and professional perspective on the best methodology to apply in our master's thesis. He advised us to do so because a quantitative analysis based on 19 factors would have been too complicated to carry out and, especially, to analyse. Moreover, the results would not have been very interesting or relevant. Based on this, we have decided to reduce the number of factors to 10. To do this, we believe the best way to proceed is to conduct interviews with experts on consumer attitudes towards repair. The objective of these interviews would be to present the 19 theoretical factors to each expert and ask them to select, and justify, the 10 factors they think are most important on consumers. Once a sufficient number of answers have been collected, the 10 most frequently recurring factors can be selected. Unfortunately, due to lack of time, we did not have time to do this. We therefore thought of another way of selecting the 10 theoretical factors most influential on consumers. Firstly, following Professor Gordy's advice, we focused more on consumers, and therefore selected the factors most directly related to them. Secondly, we have based ourselves mainly on the analysis and ranking of factors from a recent article by Roskladka, Jaegler and Miragliotta (2023) but also on others such as Terzioğlu, Brass and Lockton (2015) and Lefebvre, Lofthouse and Wilson (2018). All three, through market research, classified factors based on their importance. Thirdly, we also looked at the number of times that a factor was addressed in the scientific literature.

This second phase has enabled us to select the 10 most influential theoretical factors and to formulate 10 hypotheses that will be tested in our empirical analysis. These hypotheses consist of an affirmative sentence saying that a factor X_i has a significant influence on

consumers' repair and replacement propensities. Furthermore, in a desire to analyse the influence of socio-demographic criteria on the propensity to repair, but also on all the factors that could potentially influence it, we have added eight sub-hypotheses that will also be tested in our empirical analysis. These sub-hypotheses also take the form of an affirmative statement saying that there is a difference between gender and/or age categories in the importance attached to the factor X_3 to X_{10}. A list of these 10 hypotheses and eight sub-hypotheses can be found below:

- **Hypothesis 1:** Consumer's gender has a significant influence on consumers' repair and replacement propensities.
- **Hypothesis 2:** Consumer's age has a significant influence on consumers' repair and replacement propensities.
    - **Hypothesis A:** There is a gender and/or age categories difference in the importance of environmental concerns on consumers' decision to repair a smartphone.
    - **Hypothesis B**: There is a gender and/or age categories difference in the importance of economic attachment to a smartphone on consumers' decision to repair it.
    - **Hypothesis C:** There is a gender and/or age categories difference in the importance of financial factors on consumers' decision to repair a smartphone.
    - **Hypothesis D:** There is a gender and/or age categories difference in the importance of time and effort on consumers' decision to repair a smartphone.
    - **Hypothesis E:** There is a gender and/or age categories difference in the importance of lack of spares parts on consumers' decision to repair a smartphone.
    - **Hypothesis F:** There is a gender and/or age categories difference in the importance of lack of technical information on consumers' decision to repair a smartphone.
    - **Hypothesis G:** There is a gender and/or age categories difference in the importance of factors related to repair services on consumers' decision to repair a smartphone.
    - **Hypothesis H**: There is a gender and/or age categories difference in the importance of product differences on consumers' decision to repair a smartphone.
- **Hypothesis 3:** Environmental concerns has a significant influence on consumers' repair and replacement propensities.
- **Hypothesis 4:** Economic attachment has a significant influence on consumers' repair and replacement propensities.

- **Hypothesis 5:** Financial factors have a significant influence on consumers' repair and replacement propensities.
- **Hypothesis 6:** Repair time and efforts have a significant influence on consumers' repair and replacement propensities.
- **Hypothesis 7:** Lack of spare parts has a significant influence on consumers' repair and replacement propensities.
- **Hypothesis 8:** Lack of technical information has a significant influence on consumers' repair and replacement propensities.
- **Hypothesis 9** Factors related to repair services have a significant influence on consumers' repair and replacement propensities.
- **Hypothesis 10:** Product differences have a significant influence on consumers' repair and replacement propensities.

(3) Phase 3: Empirical (quantitative survey) and qualitative analysis

Phase 3 is our analysis in the strict sense of the term, and consists of an empirical and quantitative analysis using regression analysis and Anova 2 tests followed by semi-structured qualitative interviews. Nevertheless, before proceeding with this analysis, a quantitative questionnaire is required. You will find more information on how we developed it in the second sub-section of this methodological part. This empirical analysis will help us to confirm or refute the 10 hypotheses and eight sub-hypotheses formulated previously. It will also enable us to identify which of the 10 theoretical factors selected have a significant impact on consumers' repair decisions and to see if there is a gender and/or age categories difference in the importance attached to repair propensity and each of the selected factors.

Quantitative analysis

The quantitative part is divided into three different analyses. The first one is a multiple linear regression which models a response Y as a function of explanatory variables X_i ($i \in \{3, 4, \dots, 10\}$) while the second is an Anova 2 test to see whether the X_1 and X_2 factors have a significant impact on consumers' propensity to repair. We have decided to exclude factors X_1 and X_2 from the multiple linear regression and to analyse it alone in another test, for simplicity's sake. In our analysis, Y represents consumers' propensity to repair and X_i corresponds to the 10 most influencing theoretical factors selected in Phase 2. The third part is an analysis, also using Anova 2 tests, of the potential difference between gender and/or age categories on the importance given to all other selected factors.

We used a linear regression model as it remains one of the most commonly used models in statistics for its simplicity and flexibility. The p-value was used as an indicator of the influence of the factor in our regression. The multiple linear regression model is written as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \epsilon.$$

For more details about this regression model and the use of the p-value, see Appendix 6.

With this theoretical background, we can carry out a multiple linear regression with factors X_3 to X_{10} in order to identify those that have a significant impact on Belgian consumers when it comes to repairing their smartphones. This multiple linear regression will be carried out in two methods, “Enter” and “Stepwise”, involving a different way for selecting the significant factors. With regard to the analysis of X_1 and X_2 factors in relation to consumers' propensity to repair, we will perform an Anova 2 test. This test enables us to identify the main and interaction effects of gender and age on the consumers’ repair propensity. Furthermore, in our desire to go further in analysing the factors influencing consumers' repair decisions, we want to examine whether there is a difference between men and women and/or between different age categories with regard to the eight other selected factors. To do so, we will also carry out eight other Anova tests. This will also enable us to conclude on the influence of gender and age categories on factors X_3 to X_{10}. For example, men might consider economic attachment to be an important factor influencing their decision to repair, while women might not perceive it as very significant.

Qualitative analysis

With regard to qualitative analysis, it consists of semi-structured interviews with the most interesting sample units from the quantitative analysis and aims to reveal the underlying reasons for their responses. Indeed, a quantitative analysis allows us to project the results to the target population in its entirety, explaining "how much" and "how", while a qualitative analysis allows us to explain the "why", the underlying reasons for consumers' behaviour (Gordy, 2023). An important point to make here is that, for lack of time, this qualitative analysis will not be conducted in this master’s thesis. Nevertheless, we will describe how we see it, in order to give another researcher the opportunity to take up our work. Consequently, for the purpose of our research, we have decided that individual interviews should be conducted, and more specifically semi-structured interviews. Traditionally, this type of interview lasts between 30 and 45 minutes, and the number of interviews depends on the saturation of information needed. In other words, if the researcher learns nothing new during an interview, he can stop there. In this type of interview, a structured questionnaire is developed in advance, listing the topics to be addressed and their order. This interview guide should follow a funnel approach, moving from very general topics to more specific ones without closed or leading questions. A typical structure is found in Appendix 7. This guide needs to be tested before it can be launched in practice. We have not developed such an interview guide here, as it will depend on the results of the quantitative analysis carried out earlier.

(4) Phase 4: Visualization of factor priority

The phase 4 aims to visualize the priority between the different selected factors, and to facilitate the work for the following phases and reader comprehension. After obtaining the results of the analysis itself, the idea is to create a visual pyramid ranking the factors according to their importance and influence on consumers’ repair propensity and therefore in their

decision between repair and replacement. This was inspired by Roskladka, Jaegler and Miragliotta (2023).

(5) Phase 5: Review of the initial theoretical framework

The fifth phase corresponds to the revision of the initial theoretical framework by comparing the results obtained in the qualitative (Phase 2) and quantitative (Phase 3) studies with the findings of our literature review. This process enables us to retrospect on the significant factors that influence the decision that consumers make when faced with a broken product. This phase aims to create a final framework that includes only those factors that are significant to Belgian consumer's repair decision. This phase was inspired by Lefebvre, Lofthouse and Wilson (2018).

(6) Phase 6: Identification of solutions

The last and sixth phase aims to increase the number of positive repair decisions made by consumers. To achieve this, we will provide a series of solutions about the factors that have the greatest impact on consumers' repair decisions but also on a more general scale. The aim of our master's thesis is not only to identify the most key factors influencing consumers' decision to repair but also to make a positive contribution by proposing concrete solutions to these factors to encourage consumers to repair more often their smartphones. Some solutions will be inspired by the quantitative study and our literature review but could also have come from the qualitative studies if it they were conducted.

3.2 Structured quantitative questionnaire

In this 6-phases methodology, primary and secondary data are collected both qualitatively and quantitatively. Qualitative data comes from all our readings on the research topic, which have enabled us to develop a theoretical framework. It is considered as secondary data, because it is information that is already available. The second type of qualitative data collected comes from the individual interviews we explained above. This is considered primary data, as it is new information that we generate ourselves. The quantitative data collected are also primary data and were gathered via an online survey using a structured questionnaire.

3.2.1 5-parts quantitative questionnaire

The structure of this quantitative questionnaire is divided into five parts, beginning with a presentation of the interviewer, the survey and its legal framework. Like the qualitative questionnaire, it uses a funnel approach. All questions are coded with a number to facilitate recognition and transcription of results. The second part concerns the filter questions, which determine whether the respondent can provide the information needed. In this research, if the respondent is a Belgian or mainly lives in Belgium, owns a smartphone and is more than 18 years old, he or she is considered as relevant. After these filter questions, the third part consists of a more detailed identification of the respondent. It should be noted that these questions relate to the first and second factors, namely consumer's gender and consumer's age.

The fourth and most interesting part of the questionnaire includes specific questions that take the form of a 7-Likert scale which enables respondents to give a precise answer on the option that best matches their attitude. Firstly, a question was developed to measure respondents' propensity to repair, with a scale ranging from "Never" to "Always". Then, nine questions on the selected factors were asked, on a scale ranging from "Strongly disagree" to "Strongly agree". We have also added an optional question where respondents can give their e-mail address in order to be contacted again for the qualitative interviews explained above. Note that questions 11 and 15 are two reverse items. This means that the questions are exactly opposite, and are designed to check the respondent's consistency and reliability. If the respondent chooses the same answer for these reverse questions, he or she is considered unreliable, and are therefore removed from the data used. Naturally, the answers to only one of the questions will be used in the regression analysis. The final phase is to conclude and acknowledge respondents. A complete example of this quantitative questionnaire, in English and in French, can be found in Appendix 8.

3.2.2 Rules for questionnaire design

Some basic rules have been respected in the design of this questionnaire. Firstly, questions must be direct (no questions with negation) and as brief as possible. Secondly, technical and ambiguous words should be avoided. Thirdly, this questionnaire must be checked by several people before launching it. This verification enables to enhance it by modifying its content, and also estimates the time needed to finish it, in order to give an approximate duration to the potential respondents.

3.2.3 Sample determination

As indicated above, our sampling unit is an adult Belgian smartphone owner. Therefore, all Belgian adults who own a smartphone are part of the target population for this study. Regarding the sample size, there is a trade-off between accuracy, complexity, and cost. The answer will therefore depend on the initial budget and the time available to the researcher. It should be noted that trying to have a good representation in terms of gender proportion and age category is a good way to have a sample population that could be considered representative of the whole population. In the case of this master's thesis, it was very difficult to determine a number in advance, but we tried to get as many respondents as possible in a very short period of time by asking people close to us to answer the questionnaire and sharing it on our social media.

3.2.4 Data processing

Firstly, a check of the data collected is necessary. Indeed, in order to keep only relevant answers, some respondents were removed from the data collected. The reverse item presented above is a first way of identifying inconsistent responses. Poorly completed questionnaires and excessively short response times must also be eliminated. As the questionnaire is an online Google form, the data is automatically processed into a csv file that can be easily retrieved. Once the survey results had been obtained, and before moving on to the actual analysis, we needed to slightly transform the data in order to use it correctly and

easily in the software chosen. We opted for SPSS[3] software, which offers advanced statistical analysis and is very easy to use, making it accessible to users of all skill levels. The most important thing at this stage was to convert the word responses into numerical ones. For the gender category, Female was coded as "1" and Male as "2". For the age category, the four age groups were coded from 1 to 4, from youngest to oldest. All other variables were simply coded on a 7-Likert scale from 1 to 7. For example, the response "Strongly disagree" was coded as "1", while the response "Strongly agree" was coded as "7". Note that the three filter questions do not need to be imported.

Regarding the different types of data in SPSS, we will use three of them. Firstly, gender categories which are qualitative nominal variables. Secondly, the age categories which are also qualitative variables, but ordinal, as we can rank them, in contrast to the gender categories. Finally, the 7 Likert scale items, which are quantitative interval variables. The nature of the variables will influence and determine the types of statistical analysis that are appropriate and possible. On the one hand, all quantitative variables will be used for multiple regression and for the various Anova 2 tests. On the other hand, qualitative variables will only be considered for the Anova 2 tests.

4. Analysis

4.1 Selection of the 10 most important factors

In this first point of the analysis section, we explain why we have kept certain factors and why we have decided not to include others in our regression analysis.

4.1.1 Factors retained

Among the socio demographic criteria, the first two factors we have decided to retain are the consumer's gender and age while the consumer's level of income was rejected. Age and gender data are easy to collect through an online survey and are directly linked to final consumers and their propensity to repair. The third factor we have decided to keep is environmental concerns. This is one of the most important factors in our master's thesis since our final aim is to find and provide solutions for repairing and not replacing smartphones in order to promote the Circular Economy. Environmental concerns are also at the heart of today's society, as individuals are increasingly aware of the damage caused to the environment by the abuse of replacing products instead of repairing them. Furthermore, this factor is also at the heart of a large number of scientific articles.

The fourth and fifth selected factors are economic attachment and financial factors. The scientific literature, in particular Roskladka, Jaegler and Miragliotta (2023), agrees that the financial factor has the biggest impact on the consumer's propensity to repair. Finally, we

[3] Statistical Package for the Social Sciences

keep the economic attachment factor because it is strongly linked to the financial factor and, according to the scientific literature, greatly influencing on the consumers' repair propensity.

We have decided to keep the factor related to the time and efforts required for a complete repair as, according to the literature review, it is a real and very important barrier to repair for consumers. The results of the article from McCollough, J. (2019), which is dedicated to this factor, demonstrate its significant impact on the propensity to repair. The seventh factor we have decided to retain is the lack of spare parts, as it is among the three factors with the greatest impact on the repair propensity in two of the articles on which we based our selection. The eighth factor that we have selected is the lack of technical information because it is the third most important, according to Roskladka, Jaegler and Miragliotta (2023). The repair services factor is the ninth selected. It is one of the factors that is listed in the article from Pérez-Beli et al. (2017) as one of the main reasons for not repairing. We have also chosen to retain it as the fourth most important factor, according to Roskladka, Jaegler and Miragliotta (2023).

Finally, we have decided to keep the product difference factor because it is in the top three of the most influential according to Terzioğlu, Brass and Lockton (2015). Furthermore, according to Lefebvre, Lofthouse and Wilson (2018) and Laitala et al. (2021), the age and the quality of a product significantly influence the likelihood of repairing or replacing the product.

4.1.2 Factors rejected

The first factor we have not retained is emotional attachment because the results of several scientific studies show different implications. For instance, in accordance with Lefebvre, Lofthouse and Wilson (2018), the emotional attachment factor would have an important impact on repair actions while from the point of view of Terzioğlu, Brass and Lockton (2015), it would be totally insignificant. Moreover, according to Roskladka, Jaegler and Miragliotta (2023), emotional attachment is the sixth least influential of the 26 factors on the propensity to repair. The second factor we have decided to reject is the consumer's level of income. This factor, although directly linked to consumers, is difficult to measure. Due to the complexity of defining the scope of this factor, it would deserve a separate study dedicated solely to the implications of different income levels on the propensity to repair.

The third and fourth factors we have not retained are lack of repair skills and knowledge. The non-selection of the first mentioned is explained by the fact that Terzioğlu, Brass and Lockton (2015) show that "assembly repair", which requires no skill, is the most recurrent type of repair. Moreover, Laitala et al. (2021) report that only 18% of respondents to their survey carried out the repair themselves, while 76% of cell phone repairs were performed by someone else (see Appendix 9). Regarding the lack of repair knowledge, we have not selected it because, as indicated in the literature review section, these two factors are closely linked. Furthermore, according to Roskladka, Jaegler and Miragliotta (2023), it is one of the least influential factors in repair actions. The next two factors we have agreed to remove are legal factors - Intellectual Property Laws and the lack of tax initiatives and fiscal incentives. Both

are among the least impactful factors according to Roskladka, Jaegler and Miragliotta (2023), and very few scientific articles mention them. In addition, Intellectual Property Laws are more difficult to apprehend for consumers as they are rather directly linked to companies. The following factor that we have not selected is the lack of repair tools as it is one of the least impactful factors on the propensity to repair according to the results of Roskladka, Jaegler and Miragliotta (2023).

The last two factors we have rejected are corporate behaviour and the lack of repair design. The first mentioned covers several concepts which are difficult to evaluate in a single factor. In addition, we are focusing on the behaviour of end consumers, and this factor is difficult to discern for them. We have also decided to reject the lack of design for repair factor because it is strongly linked to corporate behaviour. It is also difficult to assess because it is quite technical for non-specialist people. Indeed, during the pre-test of our quantitative survey, several people as well as Professor Gordy, mentioned that the general belief was that the influence of this factor was true, but this was not a personal opinion. Furthermore, according to Roskladka, Jaegler and Miragliotta (2023), several notions of this factor are the least influential on repair decisions.

4.2 Descriptive analysis of the sample

Before going into the details of the analysis of our market research results, we would like to briefly present the sample we obtained. This sample analysis is based on the two socio-demographic criteria we took into account in our survey: the consumer's gender and age. Graphs on the distribution of the sample population can be found in Figure 5 and the tables in Appendix 10.

Thanks to good sharing on social media, we have gathered 241 valid responses. Among these 241 respondents, women represent 56,8% of the population and men 43,2%. We believe that these figures are representative of the entire Belgian population, since in Belgium there are slightly more women than men (StatBel, 2023). This statement cannot be formulated with regard to the distribution of the sample's age categories. Indeed, the 18-30 year olds category, on its own, represents 57,7% of the total sample population. The second most represented category is the 46-60 age group with 23,3%, while the 31-45 and over-60 year olds both account for around 10%. The reasons why this sample is not very representative of the Belgian population will be discussed in the limitations sub-section included in the conclusion of this master's thesis. If we combine these two socio-demographic variables into a single table, we can observe that the most represented part of the population is women aged 18 to 30, followed by men in the same age category with 29,9% and 27,8% respectively. Men over 60 and between 31 and 45 are the two least represented categories, with 2,9% and 3,7% correspondingly.

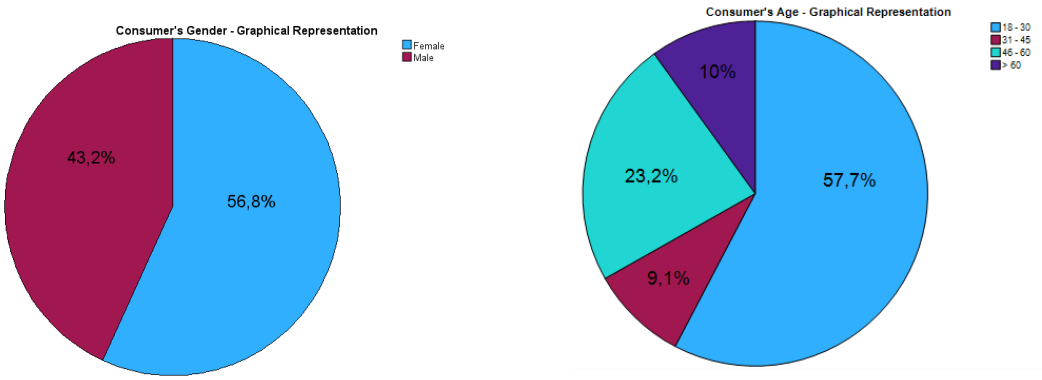

Figure 5: Sample distribution by gender and age (SPSS)

4.3 Descriptive analysis of selected factors

In order to take a first look at the data collected, we wanted to make a brief descriptive analysis of the factors X_3 to X_{10}. This analysis is performed by examining the mean, standard deviation (or variance), most and least given response of each independent variable X_3 to X_{10}. Figure 6 summarizes these descriptive statistics in one graph. A more detailed table with the statistics on the various factors can be found in Appendix 11 and all frequency histograms in Appendix 12.

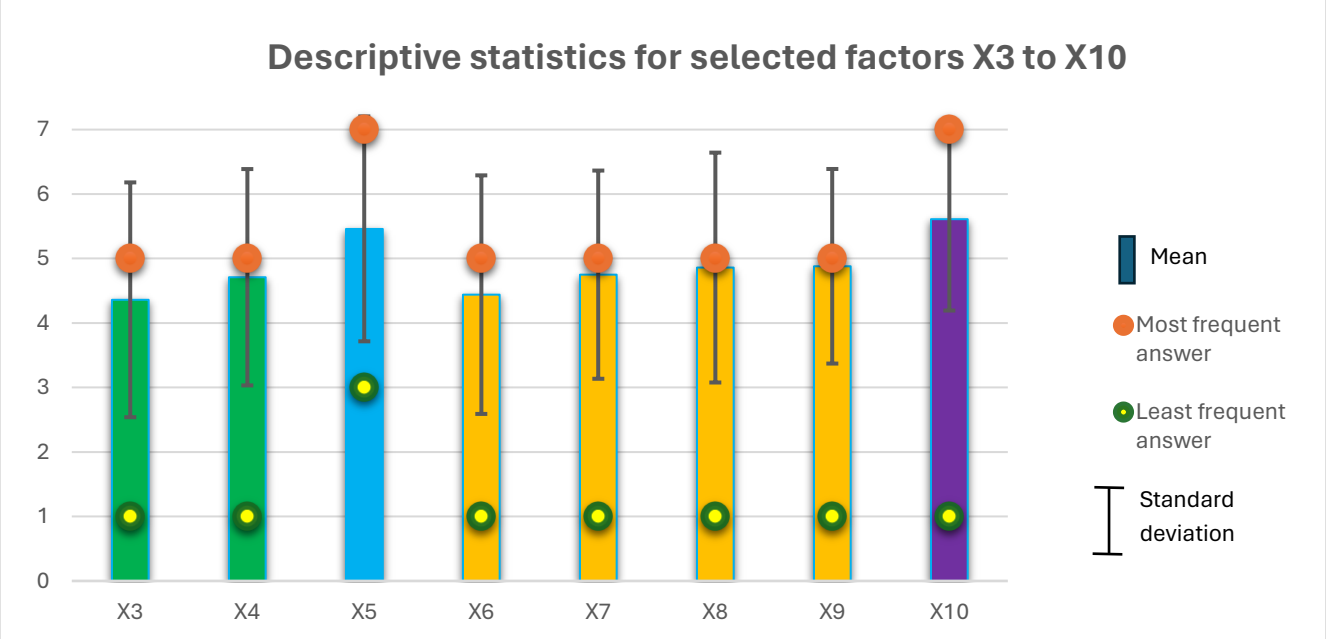

Figure 6: Summary table of descriptive statistics for factors X_3 to X_{10}

The two factors with the highest means are those related to finance and product differences with 5,46 and 5,61 respectively. These high averages can be also observed by the fact that for both factors, the most frequent answers given by our respondents are 7, corresponding to "Strongly Agree". This initial analysis seems to be aligned with the findings of Roskladka, Jaegler, and Miragliotta (2023), who consider the financial factor to be the most influential on consumers' inclination to repair. The product difference factor exhibits the lowest standard deviation, which seems to imply that it has an important influence on the repair decisions of the majority of participants. The minimum standard deviation (or variance), and

therefore low dispersion of responses, indicates a high level of consensus among respondents regarding the importance of this factor.

The environmental concerns factor has caught our attention, as it has the lowest mean, the second highest standard deviation, and the highest "Strongly Disagree" response rate compared to all other factors. At first glance, this seems surprising, as environmental concerns are often seen as one of the main reasons for positive ecological actions, such as repair. However, given that this factor has one of the highest dispersions of responses among all the factors, we cannot say that there is a clear consensus on the influence of this factor among our respondents. The last factor with interesting statistical results is repair time and the effort required to complete a repair. It has the second lowest mean, but above all the highest standard deviation (or variance). This means a stronger disparity of answers compared to all the other factors and therefore a relatively wide diversity of opinions on the influence of time and efforts on consumers' repair decisions. These results show that people see time very differently, as this notion is very specific to each consumer. At first sight, this correlates with the findings of McCollough (2019), who asserts that the busier people are, especially with their professional activities, the more they will opt for a replacement of their product rather than taking the time to repair it.

This preliminary descriptive analysis of the data has facilitated the identification of the most intriguing results. Nevertheless, this initial analysis does not enable us to identify the significant factors influencing the propensity to repair smartphones, which is rather the role of the regression analysis explained just below.

4.4 Regression analysis

The linear regression method will provide us, a model that explains the relationship between a dependent variable (the consumers' repair propensity) and the independent variables (factors X_3 to X_{10}). After having verify the validity of the model, this analysis will enable us to retain the best linear regression model in order to identify significant influencing factors.

4.4.1 Regression model validity

To be confident that a model is accurate, we need to check its validity. This requires an analysis of the residuals, the possible collinearity, the homoscedasticity, the Variance Inflation Factor (VIF) and the adjusted R-squared (Pleyers, 2023). Multiple linear regression must meet certain conditions, whose second and third correspond to the residuals, collinearity, and homoscedasticity of the residual variance.

The conditional expectation of the residual with respect to the factor X_i must be zero. The normality of the residuals graph from SPSS allowed us to visually verify the first interpretation of the residual conditional expectation. Based on the assumption that the distribution of the residuals is normal (Pleyers, 2023), it is expected to observe a clustering of points around the horizontal line. In Appendix 13, we can observe this clustering which indicates that the residuals follow a normal distribution.

The VIF allowed us to easily assess the second interpretation of the residual conditional expectation. Indeed, the VIF analyses the collinearity among factors which appears when the explanatory variables evolve together which possibly generates inaccurately estimated parameters and creates parameter instability when an input changes. If the VIF is higher than 10, it means that there is a significant multicollinearity that would need to be corrected by removing one or more explanatory variables (Candelon, 2022) (Pleyers, 2023). As we can observe in Appendix 14, the VIF values of our model lie between the range of 1 to 2. This indicates that there is a reduced or no collinearity between the explanatory variables and then, no need to remove explanatory variables.

To meet the last condition, we must ensure the model is homoscedastic which means that the variance $VAR(Y_i|\epsilon_i)$ is homogeneous, i.e., it is the same for all explanatory variables X_i. To verify this, SPSS generates a graph displaying the residuals' concentration. Appendix 15 shows a concentration of 95% of the residuals between -2 and 2, which validates the hypothesis of homoscedasticity (Pleyers, 2023).

To further enhance the validity of the regression model, the Marketing Research course from Professor Pleyers (2023) introduced to us an Anova test. This test helps determine if the independent variables used in the model effectively explain the dependent variable. The table in Appendix 16 displays a p-value that is less than the alpha level (<0,05), indicating that the model is accurate. Note that this Anova test has no influence at all on the Anova 2 tests discussed below.

In our analysis, we follow two methods of regression: Enter and Stepwise. In the first one, we kept all the explanatory variables and analysed the outputs from SPSS software while in the second method, we select a combination of explanatory variables that gave us the best adjusted coefficient of determination (adjusted R-squared, $\bar{R}^2$). This decision to use the adjusted R-squared and not the coefficient of determination (R-squared, R^2) is driven by the fact that it is a better indicator of the quality of a regression, especially when it involves a large number of independent variables. On the one hand, by its statistical definition, R-squared (R^2) tends to increase every time we add a predictor to the model, even if the predictor is of poor quality. On the other hand, adjusted R-squared ($\bar{R}^2$) increases only when a new predictor improves the model and decreases when poor quality predictors are added to the model (Van Bellegem, 2022).

4.4.2 Complete Regression Model – First Method (Enter)

From the results, it was observed that only three factors, namely economic attachment (X_4), repair time and effort (X_6), and those related to repair services (X_9) were truly significant. Moreover, it should be noted that the environmental concerns (X_3) factor can be considered as slightly significant, as its p-value is close to the alpha level (0,05). This last finding could contradict Weaver's statement that "environmental concern did not correlate with repair propensity" (cited in Lefebre et al., 2018, p. 2034). Nevertheless, the influence of the

environmental concerns factor in the literature is not crystal clear. Some articles considered it to be a very important factor, while others argue that it does not have the desired impact.

All other factors did not show a p-value below the alpha level (0,05). The Figure 7 displays the p-values of all the explanatory variables using the Enter method. In terms of the signs of the estimators, those related to the environmental concerns (X_3) and economic attachment (X_4) factors are positive, indicating a positive impact on the willingness to repair. Conversely, the signs of the estimators for the repair services factor and the time and efforts factor are negative, implying a negative impact on the propensity to repair. The adjusted coefficient of determination ($\bar{R}^2$) of this first method has a value of 0,33 (see Appendix 17).

Coefficients Table of the Enter method

Model		Unstandardized Coefficients		Standardized Coefficients			Statistics	
		B	Std. Error	Beta	t	Sig.	Collinearity tolerance	VIF
1	(Constant)	3,923	,597		6,574	<,001		
	Environmental concerns (X3)	,100	,058	,104	1,723	,086	,754	1,326
	Economic attachment (X4)	,383	,062	,369	6,144	<,001	,767	1,304
	Financial factor (X5)	-,031	,056	-,031	-,548	,584	,887	1,127
	Repair time and efforts (X6)	-,231	,063	-,246	-3,694	<,001	,623	1,604
	Lack of spare parts (X7)	,052	,075	,049	,703	,483	,576	1,736
	Lack of technical information (X8)	-,073	,062	-,075	-1,180	,239	,689	1,452
	Factors related to repair services (X9)	-,165	,069	-,143	-2,391	,018	,773	1,294
	Product differences (X10)	-,038	,071	-,031	-,542	,588	,838	1,193

Figure 7: Coefficients table of the Enter regression method (Method 1) (SPSS)

4.4.3 Best Regression Model – Second Method (Stepwise)

In the second method of our regression analysis, we used the Stepwise method. This technique involves starting with zero estimators and gradually adding the most significant estimator (with the smallest p-value). SPSS repeated the process until the last estimator was reached, and then selected the model of estimators that resulted in the highest value of the adjusted coefficient of determination ($\bar{R}^2$). In Appendix 18, we can see that the best model incorporates only three explanatory factors. These factors, the same as for the Enter method, are the economic attachment (X_4), repair time and effort (X_6) and related to repair services (X_9). Thanks to the Stepwise method, we found that these three factors are considered to be the significant factors that give the best regression model. Among the three factors, only the economic attachment (X_4) factor would have a positive impact on the propensity to repair, and it has the greatest impact with an estimator of 0,410. With regards to the adjusted coefficient of determination for this new model, it did not improve in comparison to the regression model of the first method. Lastly, in the first method, we mentioned the possibility of the significance of the environmental concerns factor because of its p-value close to the alpha level. According to the results of the Stepwise method, the best model does not consider the environmental concerns factor (X_3), as it does not improve the adjusted coefficient of determination. The coefficients tables of the Stepwise method can be found in Figure 8. Despite being narrowly excluded, as its p-value is just above the alpha level (0,05),

the environmental concerns factor (X_3) is considered as slightly significant in our analysis (see Appendix 19). The adjusted coefficient of determination ($\bar{R}^2$) for this model using the Stepwise method is the same as for the Enter method (0.33).

Coefficients Table of the Stepwise method

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity tolerance	Statistic VIF
		B	Std. Error	Beta	t	Sig.		
1	(Constant)	3,898	,453		8,606	<,001		
	Economic attachment (X4)	,425	,056	,410	7,615	<,001	,957	1,045
	Repair time and efforts (X6)	-,254	,053	-,271	-4,833	<,001	,884	1,131
	Factors related to repair services (X9)	-,190	,063	-,165	-3,014	,003	,922	1,084

Figure 8: Coefficients table of the Stepwise regression method (Method 2) (SPSS)

The first and the second method allowed us to confirm hypotheses 4, 6 and 9 while the hypothesis 3 is slightly confirmed. The other hypotheses have been rejected by our regression model analysis. With regard to the rejection of the significance of the lack of technical information influence on consumers' propensity to repair, this echoes what one of our respondents said. According to him, this factor has no influence on his inclination to repair, since all information can be found on the Internet.

4.5 Anova 2 tests analyses

Before going into detail about the results of the different Anova 2 tests, we wanted to briefly explain how to conduct these tests using SPSS and analyse their outputs. For our research, in addition to the classic Anova 2 test on SPSS, we added a Bonferroni post hoc test on consumer's age and a visual graph with the three different variables involved. Descriptive analysis and estimation of the size effect are also useful.[4]

The classic Anova 2 test will show, whether there is a difference in attitude between men and women (main gender effect) and between the four different age categories (main age effect) on the results obtained for the dependent variable under analysis. For example, results may show that for the propensity to repair, there is a significantly higher score for men than for women (not considering age groups) and a significant difference in the score of the oldest category compared to the youngest one (not considering gender groups). In addition to these main effects of gender and age, the Anova 2 test will also indicate whether there is an interaction effect between these factors on the dependent variable. An interaction effect means that the effect of one variable is dependent on the other variable. For example, the effect of age on the dependent variable is only significant for the male category. To see these results on SPSS, we need to examine the “Test of Between Subjects Effects” table on SPSS, and particularly the p-value. The last column of this table is also interesting to look at, as it gives us the Partial Eta Squared.

[4] SPSS actions: [Analyse > General Linear Model > Univariate] [Option: Select “Descriptive analysis” and “Estimates of effect size” [Post Hoc: Select “Bonferroni’] [Plots: Make a plot with the 2 factors]

> "Partial Eta Squared is a way to measure the effect size of the different variables in the Anova models. It measures the proportion of variance explained by a given variable of the total variance remaining after accounting for variance explained by other variables in the model" (Bobbitt, 2021).

In other words, it is a way of seeing which indicator of the dependent variable is the best between gender and age groups alone and together. The higher it is, the better, as this means that this variable has a higher explanatory power of the results of the dependent variable (Pleyers, 2023).

If the Anova 2 test reveals a significant mean difference between age categories, a Bonferroni post hoc test on age is needed to determine between which age groups this difference is meaningful. This can be seen in the "Multiple Comparisons" table. A table summarizing the results of the Anova 2 test, discussed below, is displayed below in Figure 9.

Factors	Categories	Repair propensity (Y)	Environmental concerns (X3)	Economic attachment (X4)	Financial factor (X5)	Repair time and efforts (X6)	Lack of spare parts (X7)	Lack of technical information (X8)	Factors related to repair services (X9)	Product differences (X10)
Gender (X1)	Female Male	NO	Slightly	NO	NO	NO	NO	NO	NO	NO
Age (X2)	18-30	YES	NO	Slightly	NO	YES	Slightly	NO	NO	NO
	31-45	NO		Slightly		Slightly				
	46-60	NO		NO		YES				
	> 60	YES		NO		YES				
Gender (X1) * Age (X2)		YES	NO	NO	NO	NO	NO	NO	NO	NO

Figure 9: Summary table of the nine Anova 2 tests

4.5.1 Anova 2 test on repair propensity

The Anova 2 results about the analysis of the consumer's repair propensity will be analysed in this sub-section and those about the analysis of all the selected factors will be presented in the following sub-section. In both cases, the fixed factors are consumer's gender and age (X_1 and X_2). All the outputs of these Anova 2 tests can be found in Appendix 20.

Regarding the repair propensity variable, we can see that there is no significant difference between men and women, as the p-value is very high (0,752). However, a significant mean difference between age groups is observed, as its p-value is below 0,05. This average difference is mainly seen between the 18-30 and over-60 age groups with 4,11 and 2,96 respectively. We can therefore say that consumers aged between 18 and 30 have a greater propensity to repair than those over 60, which contradicts the results from Cerulli-Harms et al. (2018) and Lefebvre et al. (2018). In addition, the consumer's age has the highest explanatory power on his propensity to repair, with a partial Eta squared equal to 0,046, which is still not huge. Finally, there is an interaction effect between gender and age on consumers' propensity to repair, meaning that gender results depend on age categories and vice versa. All this can be visually seen on the plot, named "Estimated Marginal Means of Repair propensity (Y)", shown in Appendix 20. This test allowed us to refute the hypothesis 1 but to confirm the hypothesis 2.

4.5.2 Anova 2 tests on the selected factors (X_3 to X_{10})

Regarding, the factor X_3, environmental concerns, the results show no mean differences at all between the different age categories (p-value = 0,921) but a slightly significant mean difference between men and women (p-value = 0,093). This minor difference is in favour of women, who more than men, consider that environmental concerns about the ecological footprint of smartphone manufacturing as increasing their willingness to repair their own. Their scores are 4,67 and 3,95 respectively on a 7-Likert scale. This test slightly confirmed hypothesis A regarding gender categories.

With regards to the factor related to economic attachment to a smartphone, the Anova 2 test revealed that there is no significant mean difference neither for the gender categories or for the age groups with p-value at 0,298 and 0,107 respectively. However, a slightly significant average difference can be found between the 18-30 and 31-45 age groups. This first age group considers that economic attachment to smartphones increases their willingness to repair their own device slightly more than the second age category. This marginally significant difference is equal to 1, with 4,86 for 18-30 and 3,86 for 31-45 year-olds. Moreover, there is no interaction effect of gender and age on this factor X_4. This test slightly confirmed hypothesis B regarding age categories.

The most interesting results from the nine Anova 2 tests are those where the dependent variable is the repair time and efforts factor. The results show no significant average difference between men and women (p-value = 0,901) but reveal all the contrary for the age factor. There is a highly significant mean difference between the different age groups when explaining the results of our respondents about repair time and efforts factor (p-value < 0,001). If we look more in detail, we can see that this difference is highly significant between 18-30 and more than 60 years old, but also between this last age group and 46-60 one. The highest score on the 7-Likert scale is for the over-60s, at 5,75. This indicates that older respondents consider the time and effort required to carry out the entire repair of their smartphones to be more detrimental to their willingness to repair than younger age groups such as 18-30 and 46-60. A slightly mean difference can be indicated as significant between the 18-30 and 31-45 age groups. All this can be seen in the plot, named “Estimated Marginal Means of Repair time and efforts (X_6)”, presented in Figure 10. Indeed, the curves of men and women are quite similar while the results for the different age groups are very distinct. We can also see on this graph that there is no interaction effect of the gender and age factors on the results about repair time and efforts factor.

Our descriptive analysis has demonstrated that there is a high dispersity of respondents’ answer regarding the influence of time and efforts required on their repair propensity. The Anova 2 test shows that this difference can be explained by the age of people. Indeed, the negative influence of the time on the repair propensity of the 31-45 age category is bigger than for the 18-30. This can be found its source as people between 31 and 45 years old, who are fully in the active life with often children to look for, do not have much free time, while the younger people have more time to dedicate to other activities as repairing. They,

therefore, see the time less as a constraint that can reduce their repair propensity than more active people. This affirmation is confirmed McCollough (2019, p.38) who said that «as more time is spent working and commuting during the week, the survey participant is more likely to feel time constrained and, therefore, they are more likely to respond that they would replace". Regarding the results of the more than 60 age group, we can see that according to them the time and efforts to carry out the entire reparation of their smartphone decrease sharply their willingness to repair. This contrasts with the previous statement, but in this case, with respondents belonging to the oldest age category, we can pay more attention to the notion of effort. Indeed, as older people they might not want to make a lot of efforts to repair their smartphones. The qualitative interviews presented in our methodology could be a way to know if these affirmations are true or not. This test fully confirmed hypothesis D regarding age categories.

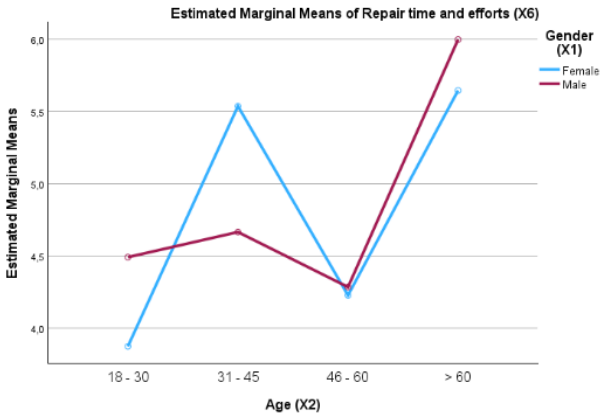

Figure 10: Estimated Marginal Means of Repair time and efforts factor (X_6) (SPSS)

The last factor that revealed significant mean difference results is the factor X_7 called lack of spare parts. Indeed, the related Anova 2 test shows that there is a significant difference in the results between the different age groups (p-value = 0,044). Even the biggest difference is located between the 18-30 and 31-45 age groups, to the advantage of the second, the post-hoc Bonferroni test reveals no significant average difference between any age category. Furthermore, the test shows, once again, no interaction effect for this factor meaning that the results for gender categories on the lack of spare parts factor are not dependent on age groups, and vice versa. This test slightly confirmed hypothesis E regarding gender categories.

Regarding the last four factors neither the gender factor, nor the age variable nor the interaction between both are significant to explain the results of the financial factor, the lack of technical information, the factors related to repair services and the product differences. This reveals that, for these four factors, there is no difference between men and women and between the four age categories to explain the attitude of our respondents regarding these factors. These tests allow us to refute hypotheses C, F, G and H.

To summarize the results of the nine Anova 2 test made on this master's thesis, we can firstly say that the interaction effects of gender and age factors on the different dependent variables are almost insignificant for all factors, with the exception of the repair propensity, for which

the results for the gender categories depend on the age groups, and vice versa. The same thing can be said for the influence of gender categories except for the environmental concerns variable for which the Anova 2 has revealed a slightly significant difference between men and women. Therefore, the most interesting factor revealing by the various Anova 2 test is the consumer's age. A highly significant difference between some age groups has been found with regards to the results of repair time and efforts factor. The results have shown that people aged over 60 considered the time and efforts required to carry out a complete repair as decreasing their propensity to repair to a greater extent than people aged between 18 and 30. However, it should be noted that for any of these tests, no factor, even significant, has demonstrated a very high explanatory power of the dependent variable.

4.6 Confirmation or refutation of the 10 hypotheses + 8 sub-hypotheses

The results of the regressions analysis and Anova 2 test have revealed that only four hypotheses and one sub-hypothesis were confirmed. On the contrary, we have rejected five hypotheses and four sub-hypotheses during our analysis. The remaining hypothesis and sub-hypotheses were slightly confirmed because the results of sub-sections 2, 3 and 4 did not allow us to reject them with complete certainty. You will find, just below, a table summarizing the outputs of our regression analysis and Anova 2 tests:

Hypotheses	**Rejected or confirmed**
1. **Consumer's gender** has a significant influence on consumers' repair and replacement propensities.	Rejected.
2. **Consumer's age** has a significant influence on consumers' repair and replacement propensities.	Confirmed.
a. There is a **gender** categories difference in the importance of **environmental concerns** on consumers' decision to repair a smartphone.	Slightly confirmed.
b. There is an **age** categories difference in the importance of **economic attachment** to a smartphone on consumers' decision to repair it.	Slightly confirmed.
c. There is a **gender and/or age** categories difference in the importance of **financial factors** on consumers' decision to repair a smartphone.	Rejected.
d. There is an **age** categories difference in the importance of **time and effort** on consumers' decision to repair a smartphone.	Confirmed.
e. There is an **age** categories difference in the importance of **lack of spares parts** on consumers' decision to repair a smartphone.	Slightly confirmed.
f. There is a **gender and/or age** categories difference in the importance of **lack of technical information** on consumers' decision to repair a smartphone.	Rejected.
g. There is a **gender and/or age** categories difference in the importance of **factors related to repair services** on consumers' decision to repair a smartphone.	Rejected.
h. There is a **gender and/or age** categories difference in the importance of **product differences** on consumers' decision to repair a smartphone.	Rejected.
3. **Environmental concerns** have a significant influence on consumers' repair and replacement propensities.	Slightly confirmed.

4.	**Economic attachment** has a significant influence on consumers' repair and replacement propensities.	Confirmed.
5.	**Financial factors** have a significant influence on consumers' repair and replacement propensities.	Rejected.
6.	**Repair time and efforts** have a significant influence on consumers' repair and replacement propensities.	Confirmed.
7.	**Lack of spare parts** has a significant influence on consumers' repair and replacement propensities.	Rejected.
8.	**Lack of technical information** has a significant influence on consumers' repair and replacement propensities.	Rejected.
9.	**Factors related to repair services** have a significant influence on consumers' repair and replacement propensities.	Confirmed.
10.	**Product differences** have a significant influence on consumers' repair and replacement propensities.	Rejected.

4.7 Factor priority visualization - Factor importance pyramid

In this pyramid that provides a representation of the factors according to their importance, those at the top are the least significant, while those at the bottom, representing the base of the pyramid, are the most significant. This visual pyramid can be seen in Figure 11.

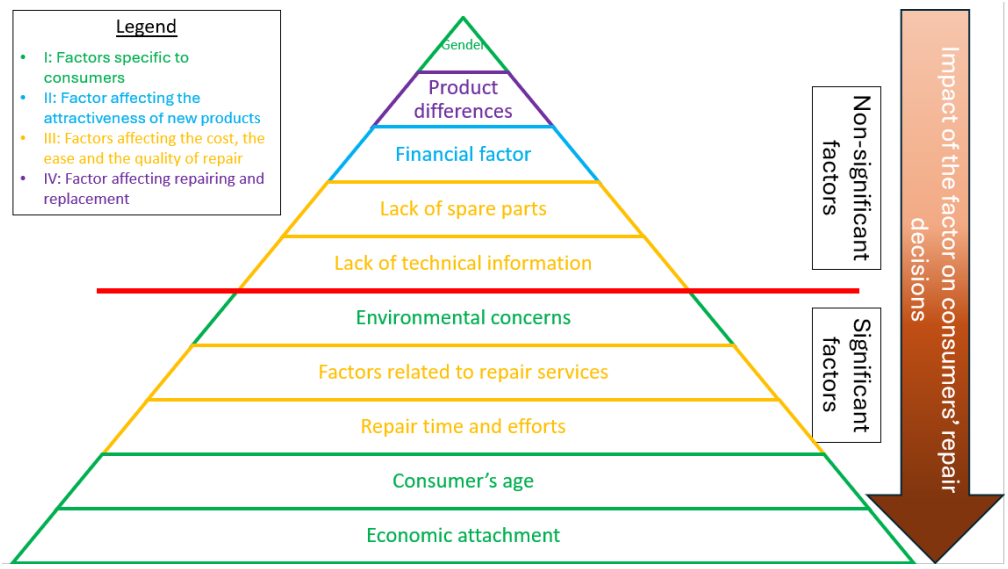

Figure 11: Consumer barriers/factors to repairing a smartphone ordered by importance (SPSS)

Among the 10 selected factors, the regressions and Anova 2 tests has revealed, respectively, that the two most significant factors were economic attachment and consumer's age. It is why we have decided to place them at the bottom of the pyramid. They both belong to the same category of factors that are factors specific to consumers.

The third factor in the pyramid is the repair time and efforts factor, which falls under the category of factors that affect the cost, ease, and quality of repair. It is ranked third because it is the second most significant factor in the two different regression methods. Additionally,

it is the factor that showed the most interesting results related to consumer's age in the Anova 2 tests. In connection with this factor, a respondent to our survey contacted us to explain an experience he had when confronted with his desire to repair when his smartphone was broken. Unfortunately, the time needed to carry out this sustainable action incited him to buy a new one instead. In addition to this, he also mentioned the fact that the importance of the time factor is exacerbated by "our involuntary and imposed dependence on smartphones". For him, this dependence pushes us to find the quickest solution to have a functional smartphone, and unfortunately the replacement option is predominant. A second respondent also contacted us, indicating almost the same implication of smartphone dependency on the time and efforts factor, and therefore on his decision between repair and replacement.

The fourth factor, which relates to repair services, falls under the same category as the repair time and efforts one. Although it did not give significant results in the Anova 2 tests, it was the last factor in the two different regression analysis methods with a p-value indicating a significant result on the propensity to repair. Furthermore, the descriptive analysis has revealed that a large number of our respondents consider that the lack of smartphone repair services and their possible poor quality decrease their willingness to repair their device.

The next factor to consider is the environmental concerns, which is specific to the consumers themselves. This factor has been ranked as the fifth most important because it is the factor that we have identified as slightly significant. Moreover, according to the Anova 2 tests, this is the only factor for which men and women have significantly different results among our respondents.

The next two factors are the lack of technical information and the lack of spare parts. Both belong to the category of factors affecting the cost, ease and quality of repair. The lack of technical information factor is in sixth place, as it has a lower p-value than the lack of spare parts factor in the results of the regression analysis. In addition, the results of our survey showed that our respondents consider that the lack of technical information decreases their willingness to repair their smartphones more than the lack of spare parts. For these reasons we have decided to rank the lack of spare parts factor seventh in the pyramid.

The last three factors, which are positioned at the top of the pyramid, showed no significant results compared to the other factors. They are the financial, product differences, and consumer gender factors. The gender factor, which was only tested in the Anova 2 tests, did not show significant effects in explaining our respondents' propensity to repair. This is the reason why it is positioned at the top of the pyramid. For the other two factors, the p-value of the financial factor was found to be smaller than the product differences factor in the regression analysis. This justifies why the financial factor is placed before the product differences factor.

4.8 Review of the initial theoretical framework

The purpose of this sub-section is to review the theoretical framework that we have established thanks to our literature review. The final goal then, is to suggest a final framework (see Figure 12) that incorporates only those factors that have a noteworthy impact on consumer's willingness to repair and therefore on their decision between repair and replacement. A first obvious decision, was to eliminate the nine factors we had removed in the first sub-section of the analysis part.

By examining the significance of each factor during the regression and Anova 2 analysis, we were able to select five factors and reject the remaining five. The factors we have retained are the economic attachment, consumer's age, repair time and efforts, those related to repair services and those linked to environmental concerns. The five rejected factors correspond to those at the top of our pyramid which have the least impact on the consumer's inclination to repair. The arrow between the consumer's age factor and repair time and efforts is present to show the significant mean difference on the influence of repair time and efforts factors on the willingness to repair, between various age groups. We have not included the consumer's gender factor, and consequently the arrow towards environmental concerns, because the purpose of this framework is to show the significant factors on the repair propensity, of which gender is not one. Finally, we have included a final box, called "Solutions", which is oriented on the consumer's repair decision. In fact, as the focus is on consumers' repairing decisions, the solutions are designed to influence and increase them.

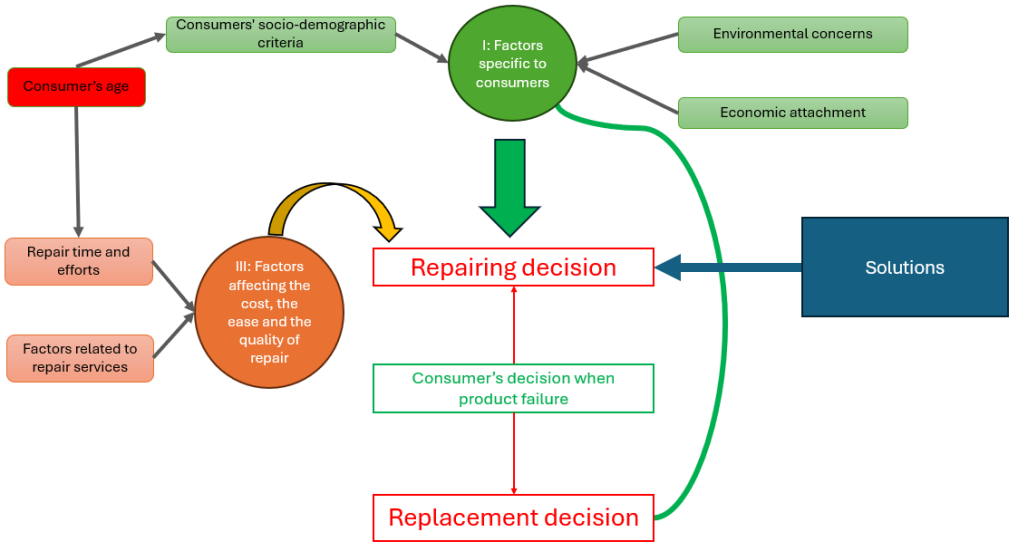

Figure 12: Final framework about factors influencing consumers' decision between repairing and replacement (SPSS)

4.9 Solutions

To identify solutions that will increase the number of repair decisions took by customers, we have made an overview of existing solutions discussed in the scientific literature which is a good way of going further with more developed and concrete solutions. Our contribution, through this master's thesis, is to provide improvements to some of these existing solutions,

to talk about existing but unimplemented solutions, and to propose new ones. In this sub-section, we will give priority to solutions for the most influential factors, as identified in the previous sub-sections. However, as most of the factors identified in the literature are interdependent, the solutions include several factors at the same time, even those we have not selected. In addition to our recommendation to extend the scope of the EU Right to Repair Directive to smartphones, we wanted to discuss about six solutions that decrease the negative influence and/or increase the positive influence of factors. In addition to that, we wanted to go a step further by proposing a final solution that would change the model, with the aim of reducing the ecological footprint of the smartphone industry. Note that our solutions are developed not only for this sector but can be considered in the vast majority of other industries.

Another very important point to emphasize is that in all the proposed solutions, the concept of coordination between the different actors is needed. Indeed, as Rogers et al. (2021, p.9) explain “expanding the repair economy is a multi-faceted endeavour, which requires coordination across multiple levels of government together with manufacturers, designers, educational institutions, community organisations, and, directly and indirectly, with individuals”.

4.9.1 Increasing product attachment

During our literature review, we have found that the emotional attachment factor is closely linked to the economic one as they are often discussed together in the scientific literature. Therefore, we will propose solutions for making products that people are attached to, care for and are motivated to repair for sentimental and economic reasons (Hernandez et al., 2020).

Firstly, to increase the lifespan of products, we suggest that designers need to consider attachment as a strategy. This involves designing products in a way that evokes a sense of attachment between the customer and the product. When the customer associates the product with its own significant value, they are more likely to take care of it (Simon et al., 2021). Moreover, when people are attached to their product, they are less inclined to make it disposable (van Nes & Cramer, 2005). Meaningful interactions between the consumer and the product can also contribute to more attachment, which can be encouraged by a Slow Design approach (Ackermann et al., 2018). To achieve product attachment, according to us, designers must find ways for consumers to form associations between consumers and their products. These associations can relate to memories or be integrated by an element of enjoyment. Designers also have a great opportunity to influence sustainable consumer behaviour by making the impact of the product and its use on the environment more explicit. To achieve this, Maclachlan (2009) has proposed a number of product attachment strategies, such as limited and very expensive editions, the manufacture of self-image products, and so on.

Secondly, we suggest using triggers from Fogg's behaviour model which states that behaviour typically results from the convergence of three factors: motivation, ability, and triggers. In the

context of this model, a trigger can be a reminder, such as a sign that tells people to perform the desired behaviour at a certain time. The trigger, called the appearance trigger, can be seen as a solution when the product's aesthetic is no longer appealing. This trigger applies to the fact that a product's aesthetics can serve as a motivator for product care. When the product loses its 'perfect' appearance, this trigger enhances the owner's motivation to take care of it and restore its aesthetics. A solution to use this appearance trigger is to create a product that a consumer could easily change the surface of their product over time (Ackermann et al., 2018). What we propose is that companies could create smartphones that can be customized with original parts or accessories, in order to encourage consumers to change the surface of their product over time and then, keep it longer.

4.9.2 Improving the financial ratio

Our second solution is to improve the financial ratio in favour of repair, and thus reduce the negative influence of the financial factor on consumers' propensity to repair. The idea is to make repair more financially attractive than buying new products, in order to increase repair decisions. This can be achieved through marketing and juridical solutions.

On the marketing level, we are proposing to make repair more convenient by reducing the cost of spare parts to make them more affordable. To do this, it's worth showing businesses that including repairs, as a core activity, in their business model is beneficial. More information on this point can be found in solution number 6, called “Producing higher quality products”. Imposing by law a maximum margin on spare parts, and abolishing VAT on them, is another way that we are considering to reduce their price. For example, if a spare part costs 10 € all in all to a company, it can only sell it for a maximum of 11,5 €, as the margin on this part is limited to 15%. A second tool, which we think marketers can use to increase the number of repair actions is to offer consumers a " no-worry-time " after they have made the purchase. During this period, whose duration needs to be determined, all repairs carried out on the product can be made free of charge for the customer (Ackermann et al., 2018). This may encourage consumers to carry out more repairs, as they know that, for a determined period of time, they will no longer pay anything for the repair of their product.

Internalizing the cost of product disposal, and more generally of pollution, of companies is something that we are suggesting to policy makers in order to increase the relative cost of new products (Scott & Weaver, 2014). By internalizing the cost of the pollution generated by the entire life of a new product, it will increase its cost and therefore its selling price. As a result, people will be more inclined to choose a more sustainable option, such as repair, since the price they will pay for a new product includes the cost of all emissions throughout the product's life cycle. This can be seen as a carbon price, which has the advantage of encouraging companies to eliminate their pollution to the greatest extent possible in order to keep their price relatively low. This may conflict with our intention to raise the price of new products in order to drive up repair activities, but as the main ultimate objective is to reduce pollution levels, it should also be considered. Moreover, it is relatively simple, as it only requires carbon accounting (Belleflamme, 2023). There are various tools for measuring this,

including the well-known "Science Based targets", which calculate CO2 emissions across three different scopes. Scope 1 covers direct emissions, while scopes 2 and 3 include indirect emissions (Marichal, 2023). More information about this can be found in Appendix 21.

In addition to the internalization of CO2 emissions, we are also proposing that political decision-makers can reduce VAT on repairs, which can take different forms. Firstly, according to us, all countries should follow the decision of several EU member states to exempt repair activities from VAT. However, the exemptions adopted by some of these member states, such as Sweden, do not apply to electronic devices (Svensonn-Hoglund et al., 2021). Therefore, we are also suggesting that these countries extend these exemptions to all smartphone repair services. Secondly, regulations can be adopted to eliminate sales tax on repair labour as well as on spare parts, as proposed above. However, Svensonn-Hoglund et al. (2021) indicates that reducing the price of repair activities had a very limited impact on consumers' willingness to repair compared to increasing the price of new products. This is why, according to us, higher VAT on new products may lead to more repair decisions. This increase may be even greater for products that are not designed to be easily repaired or maintained. The starting point for this could be the European standard for measuring the repairability of energy-related products (Laitala et al., 2021).

All these solutions to improve the financial ratio in favour of repair are great for altering prices but, according to point McCollough (2009, p.625), "a more effective response would be to increase the supply of workers within the repair trade, thus reducing labour costs and, hence, overall repair prices". This is why the following solution, which consists of increasing the supply of quality repair services, is proposed.

4.9.3 Widening offers for quality repair services

Increasing the number of quality repair services available to customers seems to be a better way of shifting the financial ratio in favour of repair than directly touching on repair and replacement prices. Indeed, increasing the number of workers in the repair industry will reduce the labour cost per employee for the repair company, and therefore the repair price (McCollough, 2009). This solution, that we are suggesting, is divided into two important parts. The first is to increase the supply of workers, while the second is to improve the quality of repair service providers in order to enhance consumer confidence in repair services. All this would reduce the negative effect of the financial factor, but also of repair service-related factors influenced by the lack of repair services and their possible poor quality.

Regarding the increase in the number of repair technicians, this can be achieved, first and foremost, by promoting training. According to us, governments should decide to create more repair schools for young adults who are seeking to study, but also for older people who are looking to reintegrate themselves into society. Moreover, repair skills can be developed as early as primary or secondary school. This will be discussed in more detail in the fifth solution, called “Educating people about repair”. All this would help to establish the repair profession and make it more widely known. Another solution that we are considering to strengthening

the recognition of the repair profession is to enhance the value of repair work. Indeed, as blue-collar work, which “is used to describe workers who perform manual labour” (Dhir, 2024), repair jobs are often perceived as less prestigious and low-skilled, whereas in reality they require highly technical skills for which workers need to be specialized and trained. To attract people as repairers, they need to be better recognized. To achieve this, governments can create more repair schools and training courses accessible to all. Additionally, we are proposing to repair companies the implementation of recognition programs for their repairers that reward their work and performance. In parallel, it is essential to continue to offer trainings and skills development to their repairers, in order to keep them up to date, but also to offer them opportunities for growth in the future (Geuens, 2023). In our opinion, more people will choose to become a repairer if they are considered and if they know they can continue to develop professionally throughout their career.

As quality repair services are fundamental to encouraging consumers to repair their smartphones, we believe that more appropriate certification and regular auditing of repair services is needed to be certain of their good quality (Roskladka et al., 2023). According to us, this approach should be inspired by the certification required in the catering industry in order to exercise its profession. Although this may constitute a barrier to competition (McCollough, 2009), we believe that this effect will be outweighed by the fact that consumers will be more engaged in repair activities thanks to their certified good quality.

4.9.4 Facilitate repair done by users and third parties

In order to increase the number of repair decisions, we are proposing that manufacturers should allow users and repair stores to undertake repairs more easily. To achieve this, we are suggesting to make spare parts readily available and repair services more convenient (Scott& Weaver, 2014) and provide more information on product durability (Cerulli-Harms et al., 2018).

We firstly recommend that governments take responsibility for imposing regulations that force companies to make access to replacement parts and product information more practical and repair-oriented. We can just think about the enlargement to smartphones, and everything that goes with it, of the European Directive on the Right to Repair. More globally, policymakers interested in promoting repair behaviour for sustainability should make repair parts and services more convenient for consumers. This would reduce the psychic and time costs associated with repairs and thereby improving consumer well-being (Scott& Weaver, 2014). The inspiration can come from the Repair Association's Model Bill which requires manufacturers of digital electronic equipment to provide documentation, parts, and tools to any independent repair provider or owner of the equipment. The model does not require a manufacturer to divulge trade secrets, except as necessary to provide documentation, spare parts, and tools on fair and reasonable terms (Jared A, 2021). Furthermore, we are also suggesting imposing standard spare parts that can be used by independent repair providers and final consumers in different smartphones. This will prevent error messages that arise from using non-original screens, batteries and cameras. The idea was also inspired by the

Repair Association's Model Bill, and by the iPhone error message problem that one of us encountered on his internship. Another solution, that we are considering, may be to put a mandatory default indicator in smartphones. Tecchio et al, 2016 (cited in Magnier, Mugge & van den Berge, 2022) highlight the importance of including a default indicator as a design intervention to support repair. Thus, through information communicated about the failure, consumers can use it to identify the steps they will need to take in order to repair their smartphone. This solution, inspired by Magnier et al., (2022), acts as a nudge that increases the information the consumers have about the failure, and then, increase their inclination to repair.

The second solution category we are suggesting to make repair more convenient involves providing more information about the product's sustainability. Some examples include using labels, default indicators, online tools for repairability calculation, and sharing useful information. Labels on products have been proven to be useful tools for providing information to consumers, as shown by a survey conducted, in 2016, by the SIRCOME agency, the University of South Brittany, and the University of South Bohemia commissioned by the European Economic and Social Committee. According to this survey, products that display information about their lifespan are chosen on average 4,6% more often compared to those without such information. Moreover, according to Braitwhaite et al. (2015) (cited in Pérez-Belis et al., 2017), durability labelling would be beneficial for both consumers and the environment by ensuring that products remain in use for a longer period of time (Pérez-Belis et al., 2017). In addition, there is a solution called the Recipe indicator, developed by Goedkoop et al. in 2013 (cited in Conny, Feng, Jaco & Marcel, 2014), which, according to us, should be used on a wider scale to evaluate the environmental impact of smartphones. It assigns a score expressed in points, where a higher score indicates a higher environmental impact. The indicator considers impact categories such as human health, ecosystem diversity, and resource availability. In our opinion, the ReCipe indicator has the potential to serve, in the future, as a valuable tool for consumer decision-making. Our recommendation is to use this ReCipe indicator, along with the indications it provides, across various products that have a considerable impact on the environment, such as smartphones. An online tool, to determine whether the smartphone can be repaired, could also be developed to support consumers in their repair decisions (Ackermann et al., 2018). By doing so, consumers can become more mindful of repairing their products rather than replacing them unnecessarily. Furthermore, thanks to the internet, companies can easily share information about product repairability and feasibility of repairs. In our opinion, by having more access to tutorial videos and blogs/websites like iFixit, people can learn more easily how to repair various products.

By making repair more convenient for consumers and independent repairers, the negative influence of the factors of lack of spare parts and technical information, but also of time and effort, on consumers' propensity to repair, will be reduced, as access to repair will be easier and therefore less time-consuming. This will also have a positive influence on the consumer's age factor, as we have seen during our analysis that certain age categories place very different

emphasis on the time and efforts required to repair their phone. Indeed, as the over-60s and 31-45s consider the time and effort required to repair their smartphones to be much more restrictive than the 18-30s, reducing this may increase their propensity to repair. In addition, by providing more information on product durability, it could increase the positive effects of the environmental concerns factor, and therefore increase the number of repair decisions compared to replacement ones.

4.9.5 Educating people about repair

A solution that we are considering and that emerges repeatedly in the scientific literature is the role of education and training in promoting repair. The first concrete solution, that we have in mind, involves creating social advertisements to encourage repair as a part of their daily routine. The main challenge is to develop a mindset among consumers that favours repair, and then establish a repair infrastructure that incentivizes them to pursue repair services (Roskladka et al., 2023). Indeed, advertising has the power to influence society towards a certain behaviour. A famous example is the anti-smoking ads developed, in the 70s, to reduce the number of smokers (Le Net, 1976).

In addition to advertising, another solution is to promote Right to Repair initiatives such as Repair Cafes and Repair Hubs, where people can find tools, materials, and volunteer who help to repair a variety of products, including smartphones. These initiatives promote community repair, which focuses on sustainability and sharing. Repair Cafes offer people a way to participate in the Circular Economy and gain more knowledge about their products (Sonego et al., 2022). Additionally, Right to Repair initiatives promote Do it Yourself (DIY) repairs, helping consumers develop repair skills and repair knowledge. In summary, Right to Repair initiatives aim to increase consumer awareness of their role in promoting sustainability by extending product lifecycles (Roskladka et al., 2023). We are therefore suggesting to create more such initiatives, but also giving them greater visibility.

A possible solution to promote repair as a profession is to include repair-related courses in both secondary and higher education. This solution can be regarded as a long-term strategy, which involves formal training to re-establish repair as a profession but also as a basic skill in school education. Our proposal is to develop repair-related courses, in the secondary school, which would be taught throughout the entire school curriculum. At higher education levels, courses for engineers, lawyers, economists, psychologists, etc. could also be a solution to promote repair. For example, engineers could have a course where they have to integrate repair into the design of a smartphone. Malz et al. (cited in Fishlock et al., 2023) developed a course for Bachelor's and Master's students in mechanical, biomedical and industrial engineering, introducing a sustainable way of thinking and training skills required to develop more sustainable solutions. The aim of this interdisciplinary approach is to promote the development of design, ecological and social competencies within the project (Fishlock et al., 2023) in order to create a product that meets the expectations of ethical and sustainable repair. Regarding other studies program, we are proposing that law students should develop a better understanding of the Right to Repair while economist students should study new

economic models to help companies integrate repair into their business model. Moreover, psychologist students should study consumer repair behaviour and translate it into effective action for companies and states. The aim of all these different students is to give a coherent and consistent thread of sustainability in order to increase the awareness and ability to solve problems using sustainable solutions as repairing.

By educating people about repair, this will increase their environmental concerns about smartphone production, and therefore encourage them to carry out more repair activities. Furthermore, Sonego et al. (2022) assert that initiatives such as Repair Cafes, in addition to enhancing product knowledge, also strengthen emotional and economic attachment to it. Finally, by implementing repair courses in secondary schools and universities, it is possible to arouse vocations and thus increase the number of workers in the repair sector.

4.9.6 Producing higher quality products

In the scientific literature, and more specifically in article from Laitala et al. (2021), we have seen that repair is more likely when consumers perceive that they own a high quality product. This is the aim of the sixth solution that we are proposing: producing better-quality products to improve their lifespan and consumers' willingness to repair them. However, a big question remains: how can we actually force companies to produce higher quality products? While this question would merit longer attention in a single paper, we will propose two ways of answering it in this master's thesis.

Firstly, according to us, the European Union, in consultation with businesses, should draw up more detailed regulations on a minimum quality for smartphones. This minimum quality standard should be higher than currently, in order to encourage companies to produce electronic devices that will last longer. Smartphones covered by these regulations should display a visible label attesting to their high quality. Given the effectiveness of labels and as consumers will know that they are made of high-quality components, this will encourage them to buy more environmentally-friendly smartphones, and to repair them more often if their screen, battery, etc. are broken. Obviously, by being forced to produce better quality smartphones, the price will increase, causing social issues as it may be difficult for people with lower incomes to buy them. However, companies, governments and states should demonstrate to this type of consumer that buying high quality products will cost them less in the long term, as they will keep their smartphones longer, not forgetting that they can be repaired.

Secondly, in our opinion, one of the ways to encourage companies to reduce the cost of their spare parts, but also to push them to produce better quality smartphones and integrate repair into their business model, is to prove that repair can be beneficial to them. Indeed, repair activities can be a new source of revenue for companies (Hernandez et al., 2020) and a way of diversifying their production, as it increases consumer loyalty. Moreover, it enables them to offer a higher price for their products, since consumers know that broken components will be repaired. This would be beneficial for manufacturers, as their revenue stream would be

spread over the life of the device and no longer reserved for sales (Rogers et al., 2021). Organizations that integrate repair as a core activity of their business model will have a competitive advantage over others, as reparability is “an attractive way to approach and get to know their users and their own products better” (Hernandez et al., 2020, p.12).

As in a situation where there is no warranty, the consumer will choose the replacement option (Laitala et al., 2021), we are proposing, simply, to impose a warranty on the repair of all components over a long period of time for all new smartphones purchased. Furthermore, on the basis of an article from Ackermann et al., (2018), we are suggesting to impose an obligation on companies to extend the existing warranty if a repair is carried out. For example, if the repair warranty on a new smartphone is around three years, any activation of it will result in its extension for an additional year. This would motivate consumers to choose the repair option more often, as they know that they benefit from a repair warranty and that it will be extended. We are aware that this solution may seem utopian, which is why we think it would be a good idea to start by establishing that the first activation of the warranty would result in its extension for a further one year.

All these solutions, aimed at producing better quality products, will obviously reduce the negative influence of the product differences factor on consumers' repair propensity. In addition, it will also increase the positive effects of the economic attachment factor, as people will pay more for their smartphones and therefore be more economically attached to them.

4.9.7 Product Service System (PSS)

The last solution that we are proposing, relates on all the different factors, since it calls for a change in the consumption system towards a more sustainable model. What we recommend is a shift in business model to a functional economy, and more specifically to a Product Service System (PSS). A PSS is composed of three key elements which are, as the name suggests, a product, a service and a system. It is based on the fact that companies should no longer sell the product itself, but its function, because consumers do not need to own things, but rather benefit from using them (Ackermann et al., 2018). There are three sub-categories of PSS: product-oriented PSS, use-oriented PSS and result-oriented PSS. The first, and most interesting in our case, is product-oriented PSS, where companies provide a service in addition to the purchase of the good, such as repair and maintenance activities. The second is use-oriented PSS, in which consumers can rent, share, etc. a product without owning it. More information about PSS can be found in Appendix 22. The advantages of such a system are considerable. There are, of course, ecological benefits, such as reduced use of natural resources, but also economic gains, such as increased profit margins, long-term customer loyalty through improved brand image, and so on. Moreover, there are also technical benefits, as it drives innovation and improves product lifecycle management (Mossay, 2023). Finally, there are social advantages because a PSS can foster employment in the repair industry (Sonego et al., 2022).

At this stage, it is important to note that this proposed solution is more global than focused on the smartphone industry, due to the daily use of such product. However, in our opinion, by integrating a product-oriented system into their business model, smartphone manufacturers could sell not only a product, but also all the services that go with it, with repair being the most important of them. In addition, we can imagine a use-oriented system with long-term leasing of smartphones. For example, people who need the latest cutting-edge phone, because they work with it, can rent it for two years before lease the next cutting-edge smartphone. What changes compared to a traditional model is that, since the smartphone is rented and not owned, after these two years it returns to the hands of the company, which can rent it out, once again, to people who do not need the latest high-performance smartphone. To achieve this, digital platforms can be used to connect businesses and consumers and thus reduce e-waste by making smartphone sharing accessible and feasible (Belleflamme, 2022).

5. Conclusion

The theoretical analysis has enabled us to identify 19 different factors that have an impact on consumer's propensity to repair and to develop a theoretical framework composed of these 19 factors grouped into 4 different categories.

Thanks to our analysis results, we were able to identify five factors, among these 19 factors, that showed a truly or slightly significant influence on consumer's propensity to repair. The factors, which showed a significant p-value in the regression analysis or in the Anova 2 tests, are economic attachment, consumer's age, repair time and efforts, those related to repair services and those related to environmental concerns. Economic attachment and consumer's age factors have revealed a very significant impact on the consumer's propensity to repair. Consumer's age and repair time and efforts factors have shown, during the Anova 2 tests analysis a significant mean difference between age categories 18-30 and over 60, and between age categories 46-60 and over 60. These results can be explained by the fact that people perceive the notion of time very differently, depending particularly on their age. In other words, people who are fully in working life view time very differently from those who are retired. These firsts results allowed us to strongly confirm hypotheses related to economic attachment, consumer's age factors and the sub-hypothesis related to repair time and efforts factor:

- *Economic attachment has a significant influence on consumers' repair and replacement propensities.*
- *Consumer's age has a significant influence on consumers' repair and replacement propensities.*
    - *There is an age categories difference in the importance of time and effort on their decision to repair a smartphone.*

Moreover, for the same reasons, our results on the repair time and efforts and the repair services factors allowed us to confirm the following hypothesis:

- *Repair time and efforts have a significant influence on consumers' repair and replacement propensities.*
- *Factors related to repair services have a significant influence on consumers' repair and replacement propensities.*

The last factor that we kept from the analysis is the environmental concerns one, as we considered it as slightly significant. Indeed, despite Weaver's statement which claims that "environmental concern did not correlate with repair propensity" (cited in Lefebre et al., 2018, p. 2034), some other articles argued that the environmental concern has a significant impact on the propensity to repair. Then, our results allowed us to slightly confirm a fifth and last hypothesis:

- *Environmental concerns have a significant influence on consumers' repair and replacement propensities.*

Regarding the other hypotheses that were drawn from our readings of the scientific literature, they were rejected by our analysis.

According to the existing scientific literature, the financial factor was expected to be one of the most significant factors and therefore having the greatest impact on the consumer's propensity to repair. Even if the hypothesis related to this factor was rejected by our quantitative analysis, 80% of our respondents agreed that the financial factors have a more or less big influence on their propensity to repair. The product differences factor also showed mainly that a high proportion of respondents agreed that it influences their repair propensity and therefore their decision between repair and replacement. Despite having the highest means and being the factors considered as highly significant in our literature review, the regression analysis and Anova 2 tests results did not allow us to select them as significant influence factors on the repair propensity.

Thanks to the theoretical and quantitative analyses that we have performed, we are able to answer to our research questions: **"What factors influence consumers' repair and replacement propensities, in the Belgian smartphone sector?"**. As can be seen in the final framework (see Figure 12), the factors with a significant influence on the propensity of Belgian consumers to repair their smartphones are as follows (in order of significance):

- **Economic attachment**
- **Consumer's age**
- **Repair time and efforts**
- **Factor related to repair services**
- **Environmental concerns**

Our aim, through this master's thesis, was to go further than identifying the most significant factors on Belgian consumers' repair propensity. In fact, we wanted to identify solutions to increase their propensity to repair smartphones and therefore the number of repair actions carried out. In other words, by identifying these factors and knowing which ones significantly influence consumers' propensity to repair, companies and governments can make better decisions to achieve a more durable society and meet global sustainability goals. In this master's thesis, we propose some solutions on the most influential factors that can serve as a basis of improvement for companies and governments. We consider the Product Service System (PSS) solution to be one of the most interesting, offering a new way of consuming through a more sustainable model. This solution suggests that companies no longer sell the object itself, but the functions that the object offers. For instance, individuals who require the latest cutting-edge smartphone can opt to lease it for two years before upgrading to the next cutting-edge model, and leave their former one to people who do not need a high-tech phone. Another interesting solution is to provide repair education to people. This solution is related to the role of education and training in promoting repair. An example would be to implement repair-related course in higher education where the civil engineer would have to integrate ethical and sustainable values when designing a new smartphone. We also proposed five other solutions: producing higher quality product, facilitate repair done by users and third parties, widening offers for quality repair services, improving the financial ratio and lastly increase the product attachment.

5.1 Limitations

To make our approach more robust, we wanted to highlight the limitations of our research and the shortcomings of our methodology.

The first major limitation we have pointed out is our questionnaire. Some of the feedback emphasized that it was too complex. Indeed, we have noticed that for certain questions on the factors, the link with the dependent variable was not always very clear and easy to apprehend. In addition, the reverse question was not used to remove irrelevant respondents, as it was very poorly formulated. Given the tight deadline, we still opted to use the data collected with this questionnaire, even if it was not 100% reliable. Furthermore, some of the questions were too long and very repetitive. With this in mind, the questionnaire needs to be improved if other researchers decide to use our methodology to conduct another study. Although we would like to, due to a lack of time and technical knowledge in drawing up a quantitative questionnaire, we cannot propose important improvements to our questionnaire. However, we propose firstly to reduce the length of the questions by removing the annotations "by yourself or by a professional repairer" and specifying this once and for all beforehand. Secondly, the reverse question needs to be changed in order to make it easier to understand and use for its intended purpose. An example of a new reverse question could be: "If the cost of repairing a smartphone is the same as buying a new one, you are more likely to opt for a repair rather than a replacement". Finally, the biggest change to be made is to

establish a clear link between the consumer's repair propensity (Y) question and each of the X_3 to X_{10} factor questions.

The second limitation we wanted to point out is that we did not have the time to conduct qualitative interviews with experts in order to select, in a more appropriate way, the 10 most important factors on which the quantitative analysis was conducted. In fact, we have selected these factors using the most objective criteria, but there is still some subjectivity involved in these choices. This subjectiveness would be greatly mitigated by interviews with experts. The third limitation we wanted to address was the absence of qualitative interviews with the most interesting respondents of our survey. Although we did not have the time to conduct them, they would have enabled us to obtain more detail on our respondents' answers, and thus to make a more solid and illustrated analysis of the influence of factors on consumers' propensity to repair. Moreover, having a discussion with consumers would have helped us to find even more concrete solutions for increasing the number of smartphone repair activities in Belgium. During these interviews, we might have a discussion with respondents about concrete examples that put a brake on their desire to repair their smartphone, and therefore about concrete solutions to remedy the situation. We could also present and discuss our solutions with them, to validate them or not.

Finally, as mentioned in the second sub-section of the analysis part, we would have liked to obtain a more representative sample of age categories. In fact, Belgian demographic percentages are far from the proportion of the various age categories we have obtained. On January 1, 2023, the most represented part of the population in Belgium is the over-60s with over 25% (StatBel, 2023), whereas our sample only includes 10% of this age group. Furthermore, at the same date, the least represented age category was the 18 to 30 year-olds, at just over 10% (StatBel, 2023), whereas in our sample they accounted for 57,70%. It would have been preferable to have more or less a proportion of 25% for each age category, but as we mainly know people of our own age, the 18-30 age group was over-represented in our sample compared to the others.

5.2 Future research needs

After having discussed its limitations, several future researches emerge from this master's thesis. Firstly, as we pointed out in the limitations sub-section, our research is not 100% perfect and complete. Therefore, following the proposed methodology in its totality could be a first option for future research. When we speak of a complete methodology, we mean that the research should be carried out entirely with a perfect quantitative questionnaire and qualitative interviews conducted with the experts and most interesting respondents. Secondly, this research could be carried out with other combinations of 10 of the 19 theoretical factors identified in the literature review. For example, factors such as company behaviour or lack of repair tools could be considered instead of lack of spare parts and product differences. Interviews with experts could lead to different choices in the selection of the 10 factors to be tested. Thirdly, as mentioned above, this research can serve as the basis for a study that would focus solely on the influence of the income level factor on consumers'

propensity to repair. Future research can also be conducted on multidimensional factor, such as company behaviour or repair services, and perform a more in-depth analysis of one factor at a time. In addition, our literature review and theoretical framework can be used by other researchers to conduct more elaborate Anova tests. The idea is to start with the 19 theoretical factors and add other socio-demographic criteria, such as level of education, family and professional situation, etc. Then, Anova 1 or Anova 2 tests can then be carried out to analyse the differences between the different categories of socio-demographic criteria as a function of all the other factors. In addition, further studies can be carried out to assess the practical feasibility of all the solutions proposed in this master's thesis. Finally, the same complete research can be conducted on other products and on another market in order to have a comparison with the results obtained for the smartphone on the Belgian market.

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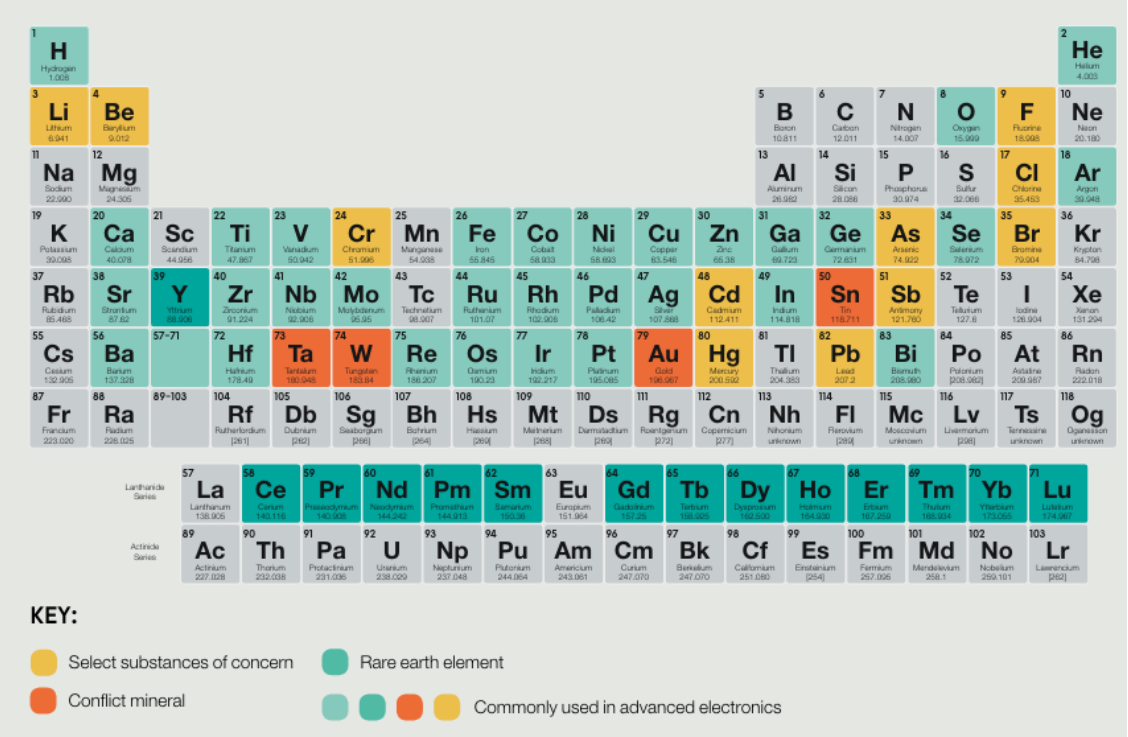
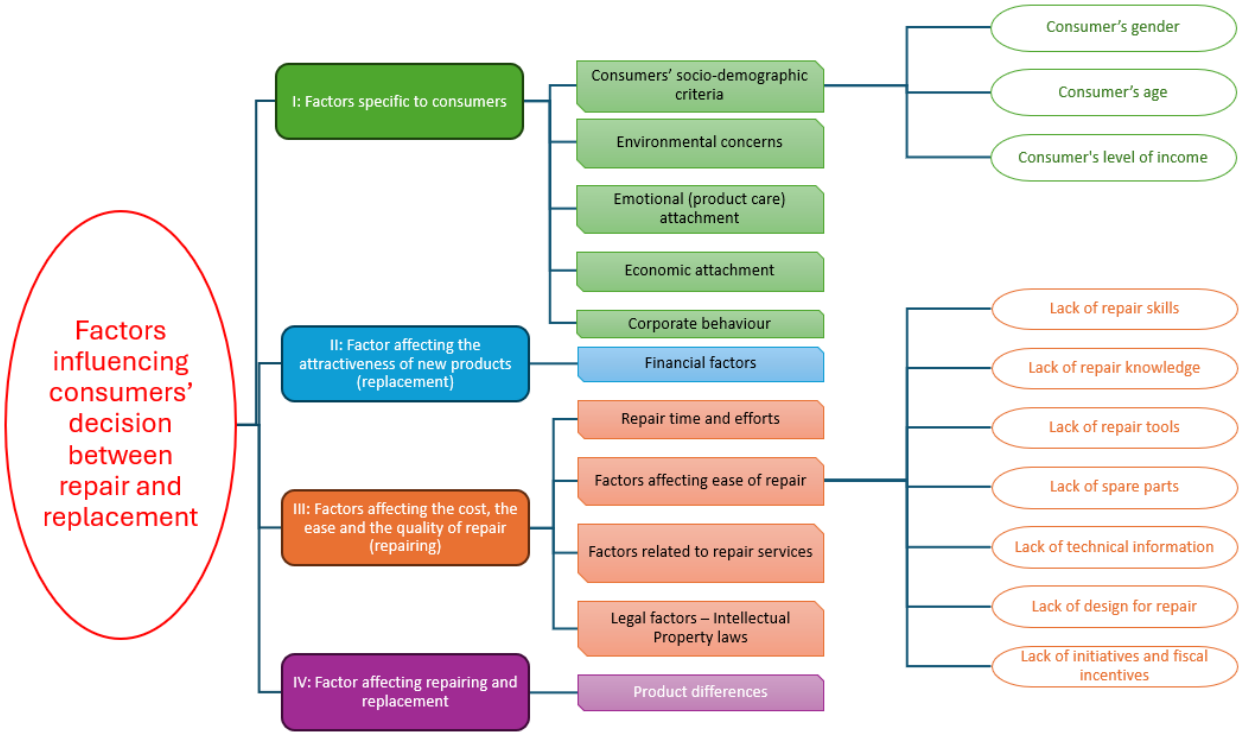
7. Appendices

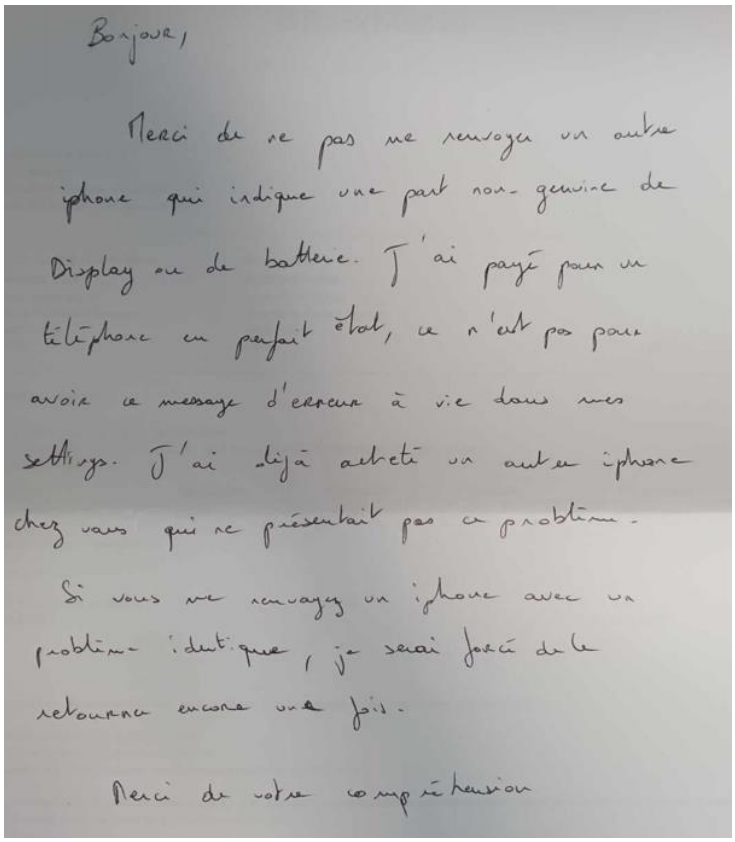
Appendix 1 – Periodic Table of smartphones (Jardim, 2017)



Appendix 2 – The 19 factors identified that influence consumers' decision between repair and replacement



Appendix 3 – Example of after sales service because of the message "non-original parts" (aSmartWorld)



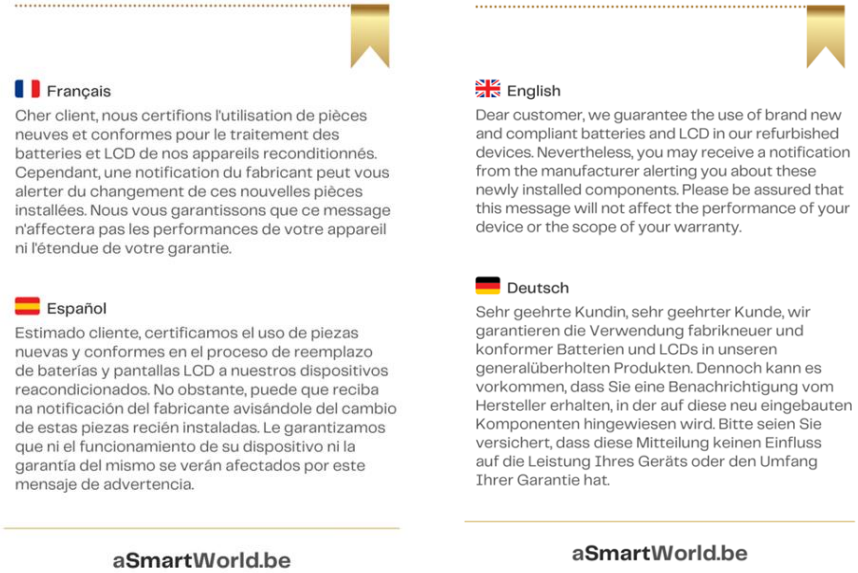
Bonjour,

Merci de ne pas me renvoyer un autre iphone qui indique une part non-genuine de Display ou de batterie. J'ai payé pour un téléphone en parfait état, ce n'est pas pour avoir ce message d'erreur à vie dans mes settings. J'ai déjà acheté un autre iphone chez vous qui ne présentait pas ce problème.

Si vous me renvoyez un iphone avec un problème identique, je serai forcé de le retourner encore une fois.

Merci de votre compréhension

Appendix 4 – Explanations of aSmartWorld about the message "non-original parts"



Français

Cher client, nous certifions l'utilisation de pièces neuves et conformes pour le traitement des batteries et LCD de nos appareils reconditionnés. Cependant, une notification du fabricant peut vous alerter du changement de ces nouvelles pièces installées. Nous vous garantissons que ce message n'affectera pas les performances de votre appareil ni l'étendue de votre garantie.

Español

Estimado cliente, certificamos el uso de piezas nuevas y conformes en el proceso de reemplazo de baterías y pantallas LCD a nuestros dispositivos reacondicionados. No obstante, puede que reciba na notificación del fabricante avisándole del cambio de estas piezas recién instaladas. Le garantizamos que ni el funcionamiento de su dispositivo ni la garantía del mismo se verán afectados por este mensaje de advertencia.

aSmartWorld.be

English

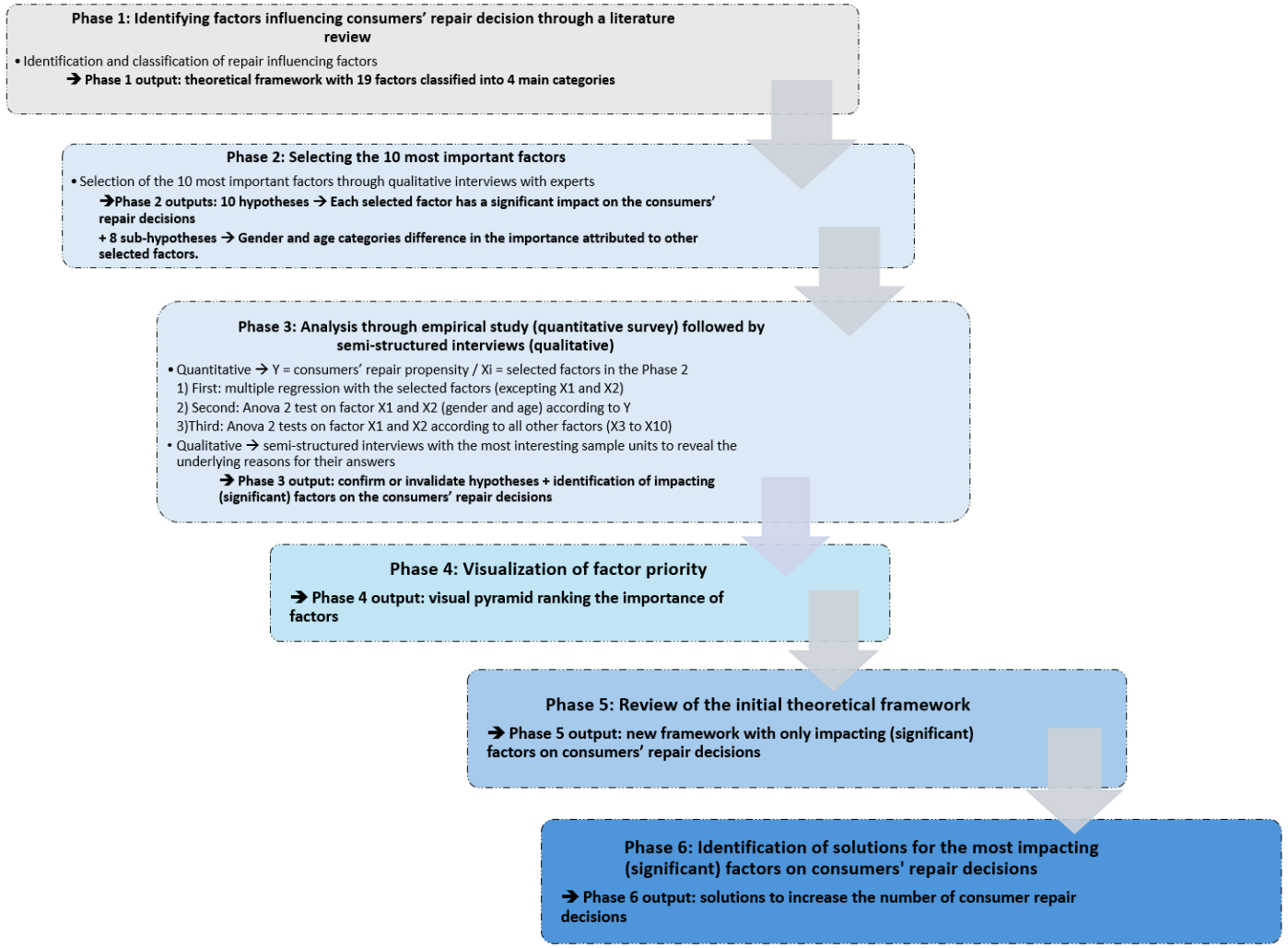
Dear customer, we guarantee the use of brand new and compliant batteries and LCD in our refurbished devices. Nevertheless, you may receive a notification from the manufacturer alerting you about these newly installed components. Please be assured that this message will not affect the performance of your device or the scope of your warranty.

Deutsch

Sehr geehrte Kundin, sehr geehrter Kunde, wir garantieren die Verwendung fabrikneuer und konformer Batterien und LCDs in unseren generalüberholten Produkten. Dennoch kann es vorkommen, dass Sie eine Benachrichtigung vom Hersteller erhalten, in der auf diese neu eingebauten Komponenten hingewiesen wird. Bitte seien Sie versichert, dass diese Mitteilung keinen Einfluss auf die Leistung Ihres Geräts oder den Umfang Ihrer Garantie hat.

aSmartWorld.be

Appendix 5 – 6-phases methodology followed in this research



Appendix 6 – Explanations about the regression model (OLS and p-value)

The linear regression is built to evaluate the influence of the independent variable(s) on the dependent variable. β is considered as an unknown parameter and is estimated by the method of Ordinary Least Squares (OLS), which is used by SPSS, the software we will be employing for our analyses. The OLS method minimizes the prediction error between the real and predicted value. The unknown parameter can take different signs and then affect positively or negatively the dependent variable. Furthermore, the β is standardized which makes the comparison between parameters easier. The independent and identical sample (Y_i, X_i) $(i \in \{1,\ 2, \dots,\ n\})$ follows a multiple linear regression if the following conditions are met for every i:

1. It exists k real coefficient $\beta_1, \dots, \beta_k$ as $\underline{Y} = X\underline{\beta} + \underline{\epsilon}$
2. The variables $\underline{\epsilon}$ are such that $E(\underline{\epsilon}|X) = 0$, meaning that the expectation of the error $\underline{\epsilon}$ is zero (first interpretation) and the error $\underline{\epsilon}$ is not correlated with the explanatory variable X_i (second interpretation)
3. The rank of the matrix X is K with probability 1

This model has homoscedastic conditional variance if there is a strictly positive real number σ such that $var(\underline{\epsilon}|X) = \sigma^2 I_n$, where I_n represents the matrix identity $n\ x\ n$.

The idea of the OLS method is to construct an estimator of β that delivers the smallest error of the given sample. We define the error as follows

$$\epsilon\left(\underline{\beta}\right) \coloneqq \underline{Y} - X\underline{\beta}.$$

We are looking for a $\underline{\hat{\beta}}$ that minimizes the sum of squares for error (SSE), which can be mathematically written as

$$SSE\left(\underline{\beta}\right) \coloneqq \underline{\epsilon}\left(\underline{\beta}\right)' \underline{\epsilon}\left(\underline{\beta}\right)$$
$$= (\underline{Y} - X\underline{\beta})'(\underline{Y} - \underline{\beta})$$

The proposition to obtain the estimator $\hat{\beta}$ by OLS from β in the multiple linear regression model is

$$\underline{\hat{\beta}} = argmin\ RSS(\underline{\beta})$$

$$\underline{\hat{\beta}} = (X'X)^{-1}X'\underline{Y}$$

By analogy with the simple linear regression, the errors after estimation are

$$\underline{\hat{\epsilon}} \coloneqq \underline{Y} - X\underline{\hat{\beta}}$$

And the sum of squares for errors are

$$\widehat{RSS} = \underline{\hat{\epsilon}}' \underline{\hat{\epsilon}}$$

$$\text{And we set } \hat{\sigma}^2 := \frac{\widehat{RSS}}{n-K} = \frac{\hat{\epsilon}'\hat{\epsilon}}{n-K}$$

In order to better understand the OLS, we computed manually an example from the simple linear regression which has the methodology that the multiple regression. In the simple linear regression, we define the error as

$$\epsilon_i := Y_i - \beta_1 - \beta_2 X_i, \qquad \forall i = 1, \dots, n$$

And the sum of squares error for the simple linear regression is

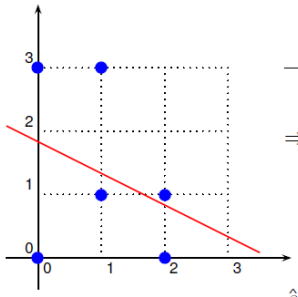
$$RSS(\beta_1, \beta_2) := \sum_{i=0}^{n} \epsilon_i^2.$$

The OLS minimizes this above equation, then by taking the derivative of $RSS(\beta_1, \beta_2)$ the estimator of the parameter β_1 *and* β_2 can be written as follows:

$$\widehat{\beta_1} = \overline{Y_n} - \widehat{\beta_2}\,\bar{X}_n$$

$$\widehat{\beta_2} = \frac{\sum_{i=1}^{n}(Y_i - \bar{Y}_n)(X_i - \bar{X}_n)}{\sum_{i=1}^{n}(X_i - \bar{X}_n)^2} = \frac{\sum_{i-1}^{n}(X_i - \bar{X}_n)Y_i}{\sum_{i=1}^{n}(X_i - \bar{X}_n)^2}.$$

Here is an illustrative example (Van Bellegem, 2022).



X_i	Y_i	$(X_i - \overline{X}_n)$	$(X_i - \overline{X}_n)Y_i$	$(X_i - \overline{X}_n)^2$
0	0	-1	0	1
0	3	-1	-3	1
1	1	0	0	0
1	3	0	0	0
2	0	1	1	1
2	1	1	1	1
6	8	0	-2	4

$\Rightarrow \overline{X}_n = 6/6 = 1$ et $\overline{Y}_n = 8/6 = 1,333$

$$\hat{\beta}_2 = \frac{\sum(X_i - \overline{X}_n)Y_i}{\sum(X_i - \overline{X}_n)^2} = \frac{-2}{4} = -0,5$$

$$\hat{\beta}_1 = \overline{Y}_n - \hat{\beta}_2\overline{X}_n = (8/6) - (-2/4) \times 1 = 1,833$$

In these three analyses, the p-value will be used as an indicator of the factors' influence on our regressions. The p-value is a measure of a probability that the data pattern in a sample could be generated by random data. In other words, it measures the degree of credibility of the null hypothesis about the observed data. Then, it indicates the likelihood of a genuine difference between the various regressions in our analysis. The lower the p-value, the less credibility will be given to the null hypothesis (Van Bellegem, 2022). The advantage is that the p-value does not require the prior definition level α to conclude a test, on basis of the same p-value, we can conclude regardless of the level α chosen (Hafner, 2020). For this master's thesis, we will use the p-value statistical cutoff of 5% or lower, which has been demonstrated

in most research as statistically significant. A p-value of 0,05 means there is only a 5% chance that we would obtain these regression results with random data (De Moerloose, 2023). This 5% will be our threshold in our different statistical analyses where we reject the factor when the p-value associated with it is higher than 0,05. Note that if a factor has an associated p-value slightly higher than 0,05, it can be considered as "slightly significant".

Appendix 7 – Typical structure of a qualitative semi-structured interviews (Pleyers, 2023)

1) Introduction	Welcome and acknowledgments, explanation of the purpose and how to operate
2) Warm-up	Participants expressing themselves on general topics that relate to the main issue of the study and regarding which they feel comfortable Aim: establish a positive climate that will be conducive to an efficient interview
3) Focus	Addressing the real subject of the study.
4) Deepening	In-depth analysis of some questions which are particularly central/interesting
5) Closure	Summary, clarifications, acknowledgment

Appendix 8 – Complete exemple of the quantitative questionnaire

In English :

(1) Part 1: Presentation of the interviewer, the survey and its legal framework

Hello,

We are two students in the second year of our Master in Business Engineering at the Louvain School of Management. As part of these studies, we are writing a master's thesis on the factors influencing consumers' decision between repairing and replacing their smartphones. In this dissertation, repair is defined as "the action of repairing a damaged, worn, or faulty product by replacing or fixing part(s) in order to prolong the lifetime of a product". It is important to keep in mind that repair can be done by consumers themselves or by professional repairers.

For this academic research, we have developed a consumer survey to better understand their repair behaviour. If you own a smartphone, are Belgian or live mainly in Belgium, and are over 18, you can take part in this survey. It should take no more than 10 minutes.

The results of this survey will only be used for our master's thesis and will be completely anonymous. Please answer each question truthfully.

At the end of the questionnaire, you will be asked to indicate your e-mail address. This will enable us to conduct a qualitative study, if time permits, to better understand the reasons

behind your responses. We therefore invite you to provide us your e-mail address. We remind you that your answers and email address will remain confidential and will only be used for our research.

Thank you in advance for your time.

Baptiste de Gottal and Luis Fernandes Brito

(2) Part 2: Filter questions

Q1: Are you a Belgian citizen or do you live mostly (more than half of the year) in Belgium?

Yes / No

Q2: Do you own and use a smartphone?

Yes / No

Q3: Are you an adult (more than 18 years old)?

Yes / No

If no, **then redirect the respondent to the end of the questionnaire** (Phase 5).

(3) Part 3: Identification of the respondents (Socio-demographic criteria)

Q4: To which gender category do you feel you belong?

Female / Male / Other / I prefer not to say

Q5: What age bracket do you belong to?

18-30 / 31 – 45 / 46 – 60 / > 60 years old

(4) Part 4: Specific questions to answer to our hypothesis

Answer this question as truthfully as possible, indicating the option that most closely matches your current behaviour. Please consider that in all the above questions, repair can be performed by the consumer himself or by a professional repairer.

Q6: If your smartphone is broken, how likely are you to repair it, by yourself or by a professional repairer, rather than replace it?

Never (in any case prefer to buy a new one) / To a very small extent / Rarely / Occasionally / Frequently / Very frequently / Always (in any case prefer to repair it)

Answer the following questions as truthfully as possible, indicating the option that most closely matches your current opinion. Please consider that in all the above questions, repair can be performed by the consumer himself or by a professional repairer.

Q7: Environmental concerns about the ecological footprint of manufacturing smartphones increase your willingness to repair yours, by yourself or by a professional repairer.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q8: Economical attachment to your smartphone increases your willingness to repair it, by yourself or by a professional repairer.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q9: If the cost of repairing a smartphone is the same as buying a new one, often with cheap options, you are more likely to opt for a replacement rather than a repair carried out by yourself or by a professional repairer.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q10: More time and efforts to carry out the entire repair of your smartphone decrease your willingness to repair it, by yourself or by a professional repairer.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q11: A lack of spare parts, replacement parts for smartphones decrease your willingness to repair yours, by yourself or by a professional repairer.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q12: A lack of access to technical information about smartphones, such as repair manuals, decreases your willingness to repair yours.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q13: A lack of smartphone repair services, their possible poor quality and past bad experiences are reducing your confidence in repair shops and, therefore, your willingness to repair yours.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q14: A difference in quality, age, and number of previous repairs of your smartphone influence your decision between repair and replacement.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Q15: The unavailability of spare parts throughout the life of your smartphone will increase your likelihood of having to repair it, by yourself or by a professional repairer.

Strongly disagree / Disagree / Somewhat disagree / Neither agree nor disagree / Somewhat agree / Agree / Strongly agree

Optional: If you are interested in this topic, you can send us your e-mail address here. This will be used to contact you if necessary, to better understand the reasons behind your answers.

(5) Part 5: Conclusions and acknowledgments

Thank you for completing this survey. It will be a great help for our master's thesis.

If you have any comments, please do not hesitate to contact us directly at one of the following e-mail addresses: baptiste.degottal@student.uclouvain.be / luis.fernandes@student.uclouvain.be

Baptiste de Gottal and Luis Fernandes Brito

In French :

(1) Partie 1 : Présentation de l'enquêteur, de l'enquête et de son cadre juridique

Bonjour,

Nous sommes deux étudiants en deuxième année de master en Ingénieur de Gestion à la Louvain School of Management. Dans le cadre de ces études, nous réalisons un mémoire sur les facteurs influençant la décision des consommateurs entre la réparation et le remplacement de leurs smartphones. Dans ce mémoire, la réparation est définie comme "l'action de réparer un produit endommagé, usé ou défectueux en remplaçant ou en réparant une ou plusieurs pièces afin de prolonger la durée de vie d'un produit". Il est important de garder à l'esprit que la réparation peut être effectuée par les consommateurs eux-mêmes ou par des réparateurs professionnels.

Dans le cadre de cette recherche universitaire, nous avons mis au point une enquête auprès des consommateurs afin de mieux comprendre leur comportement en matière de réparation. Si vous possédez un smartphone, que vous êtes belge ou vivez principalement en Belgique et que vous avez plus de 18 ans, vous pouvez participer à cette enquête. Cela devrait vous prendre maximum 5- 10 minutes.

Les résultats de cette enquête seront uniquement utilisés dans le cadre de notre mémoire et seront totalement anonymes. N'hésitez donc pas à répondre sincèrement à chaque question.

À la fin du questionnaire, vous aurez la possibilité d'indiquer votre adresse email. Elle nous servira à conduire, si le temps nous le permet, une étude qualitative afin de mieux comprendre les raisons derrière vos réponses. Nous vous invitons donc grandement à nous laisser votre adresse email. Nous vous rappelons que vos réponses et votre adresse email resteront confidentielles et seront uniquement utilisées dans le cadre de notre recherche.

Nous vous remercions d'avance pour le temps que vous nous accordé.

de Gottal Baptiste et Fernandes Brito Luis

(2) Partie 2 : Questions filtres

Q1. Êtes-vous citoyen belge ou vivez-vous principalement (plus de la moitié de l'année) en Belgique ?

Oui / Non

Q2 : Possédez-vous et utilisez-vous un smartphone ?

Oui / Non

Q3 : Etes-vous un adulte (plus de 18 ans) ?

Oui / Non

Si non, rediriger le répondant vers la fin du questionnaire (phase 5).

(3) Partie 3 : Identification des répondants (critères sociodémographiques)

Q4 : À quelle catégorie de sexe vous sentez vous appartenir ?

Femme/ Homme / Autre / Je préfère ne pas le dire

Q5 : À quelle tranche d'âge appartenez-vous ?

18-30 / 31-45 / 46-60 / > 60 ans

(4) Partie 4 : Questions spécifiques pour répondre à note hypothèse

Répondez à cette question le plus sincèrement possible, en indiquant l'option qui correspond le mieux à votre comportement actuel. Veuillez noter que dans toutes les questions ci-dessus, la réparation peut être effectuée par le consommateur lui-même ou par un réparateur professionnel.

Q6 : Si votre smartphone est cassé, quelle est la probabilité que vous le repariez, par vous-même ou par un réparateur professionnel, plutôt que vous le remplaciez ?

Jamais (Je préfère en acheter un nouveau dans tous les cas) / Très peu / Rarement / Occasionnellement / Fréquemment / Très fréquemment / Toujours (Je préfère le réparer dans tous les cas)

Répondez aux questions suivantes le plus sincèrement possible, en indiquant l'option qui correspond le mieux à votre opinion actuelle. Veuillez noter que dans toutes les questions ci-dessus, la réparation peut être effectuée par le consommateur lui-même ou par un réparateur professionnel.

Q7 : Les préoccupations environnementales relatives à l'empreinte écologique de la fabrication des smartphones augmentent votre volonté de réparer le vôtre par vous-même ou par un réparateur professionnel.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q8 : L'attachement économique à votre smartphone augmente votre volonté de le réparer par vous-même ou par un réparateur professionnel.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q9 : Si le prix de réparation de votre smartphone est le même que le prix d'achat d'un nouveau, souvent avec des options bon marché, vous êtes plus susceptible d'opter pour un remplacement de celui-ci que pour une réparation par vous-même ou par un réparateur professionnel.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q10 : Le temps et les efforts nécessaires pour effectuer la réparation complète de votre smartphone diminuent votre volonté de le réparer par vous-même ou par un réparateur professionnel.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q11 : Le manque de pièces détachées de remplacement pour les smartphones diminue votre volonté de réparer le vôtre, par vous-même ou par un réparateur professionnel.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q12 : Le manque d'accès à des informations technique sur les smartphones, tels que des manuels de réparation, diminue votre volonté de réparer le vôtre.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q13 : Le manque de services de réparation de smartphones, leur possible mauvaise qualité et les précédentes mauvaises expériences de réparation diminuent votre confiance envers les ateliers de réparation et, par conséquent, votre volonté de réparer les vôtres.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q14 : La différence de qualité, l'âge et le nombre de réparations antérieures de votre téléphone influencent votre décision entre la réparation et le remplacement.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Q15 : L'indisponibilité de pièces détachées pendant toute la durée de vie de votre smartphone augmentera votre probabilité de le réparer par vous-même ou par un réparateur professionnel.

Pas du tout d'accord / Pas d'accord / Plutôt pas d'accord / Ni d'accord ni pas d'accord / Plutôt d'accord / D'accord / Tout à fait d'accord

Optionnel : Si vous êtes intéressé par ce sujet, vous pouvez nous envoyer votre adresse e-mail ici. Celle-ci sera utilisée pour vous contacter si nécessaire, afin de mieux comprendre les raisons de vos réponses.

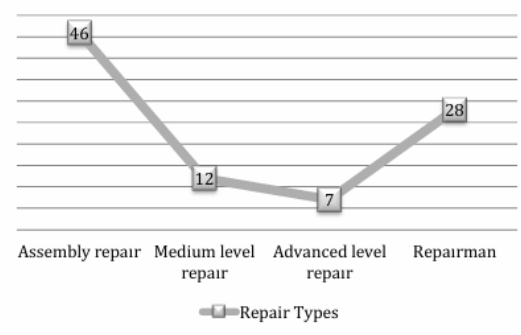
(5) Partie 5 : Conclusions et remerciements

Merci d'avoir répondu à cette enquête. Cela nous sera d'une grande utilité pour notre mémoire.

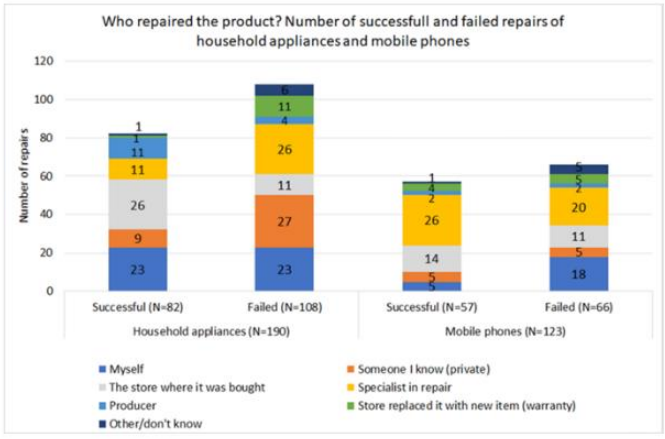
Si vous avez des commentaires, n'hésitez pas à nous contacter directement à l'une des adresses e-mail suivantes : baptiste.degottal@student.uclouvain.be / luis.fernandes@student.uclouvain.be

de Gottal Baptiste et Fernandes Brito Luis

Appendix 9 – Rejection of the lack of repair skills factor



Numerical distribution of repair types (Terzioğlu, Brass and Lockton (2015)).



Number of repairs categorized by who attempted repair and whether the outcome was successful by main product groups (household appliances and mobile phones).

Number of repairs categorized by who attempted repair (Laitala et al. (2021)).

Appendix 10 – Sample distribution by gender and age (SPSS)

Proportion of sample by gender

Consumer's Gender

		Frequency	Percent
Valid	Female	137	56,8
	Male	104	43,2
	Total	241	100,0

Proportion of sample by age

Consumer's Age

		Frequency	Percent
Valid	18 - 30	139	57,7
	31 - 45	22	9,1
	46 - 60	56	23,2
	> 60	24	10,0
	Total	241	100,0

Crosstabulation table between respondents' gender and age.

			Age (X2)				
			18 - 30	31 - 45	46 - 60	> 60	Total
Gender (X1)	Female	Count	72	13	35	17	137
		% of Total	29,9%	5,4%	14,5%	7,1%	56,8%
	Male	Count	67	9	21	7	104
		% of Total	27,8%	3,7%	8,7%	2,9%	43,2%
Total		Count	139	22	56	24	241
		% of Total	57,7%	9,1%	23,2%	10,0%	100,0%

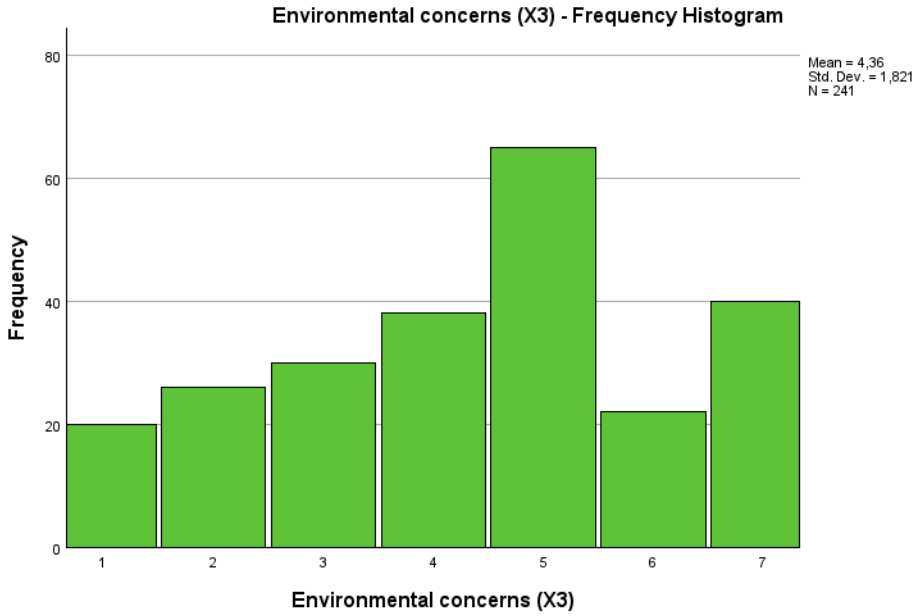
Appendix 11 – Descriptive statistics for factors X_3 to X_{10} (SPSS)

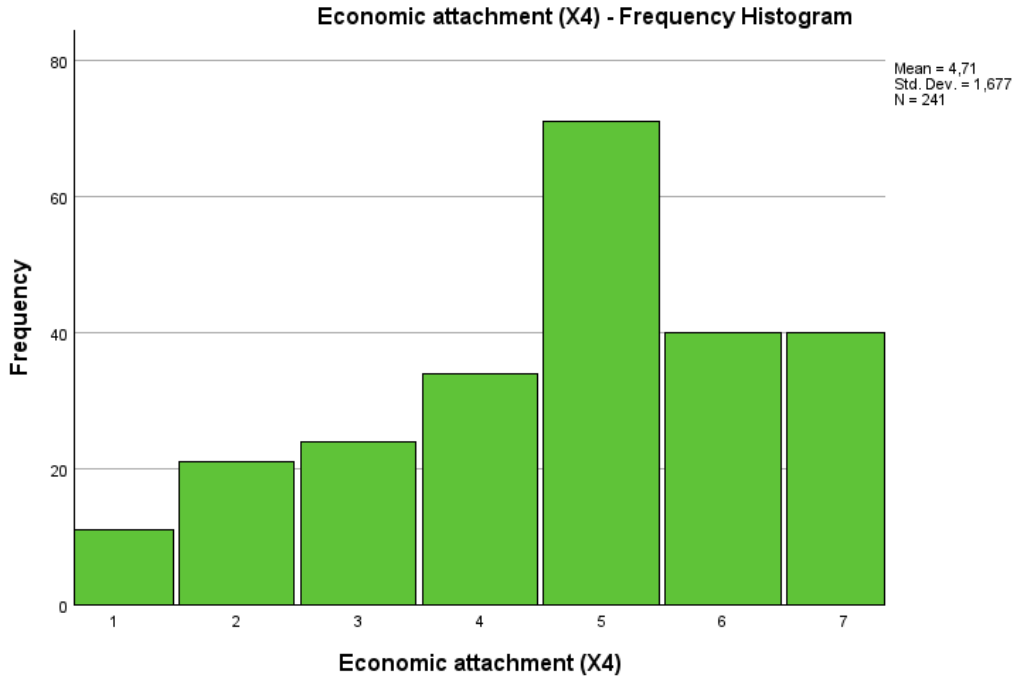
Statistics for selected factors X_3 to X_{10}

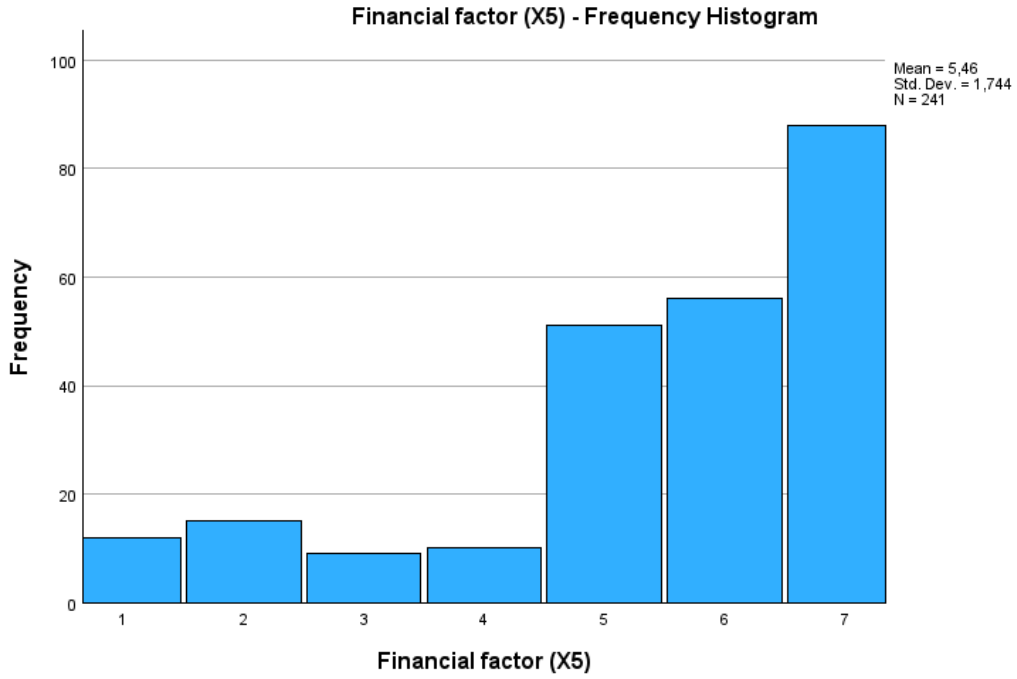
	Environmental concerns (X3)	Economic attachment (X4)	Financial factor (X5)	Repair time and efforts (X6)	Lack of spare parts (X7)	Lack of technical information (X8)	Factors related to repair services (X9)	Product differences (X10)
Mean	4,36	4,71	5,46	4,44	4,75	4,86	4,88	5,61
Variance	3,315	2,814	3,041	3,422	2,607	3,177	2,276	2,006
St.dev	1,82071414	1,6774981	1,7438463	1,8498649	1,6146207	1,7824141	1,5086418	1,4163333
Most frequent answer	5	5	7	5	5	5	5	7
Least frequent answer	1	1	3	1	1	1	1	1

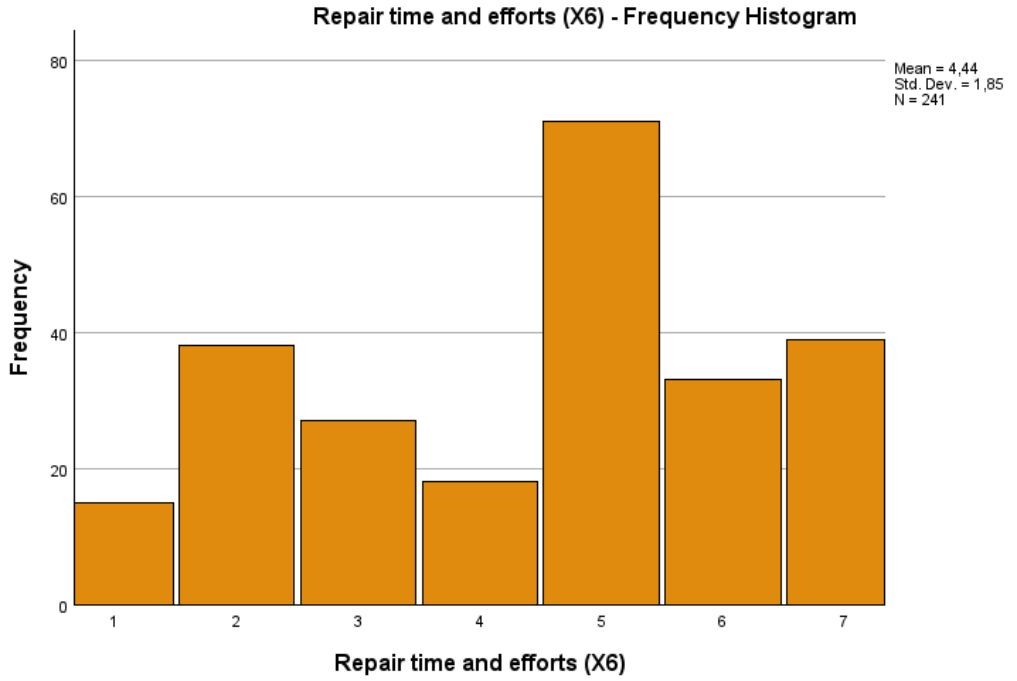
Appendix 12 – Frequency Histogram of factors X_3 to X_{10} (SPSS)

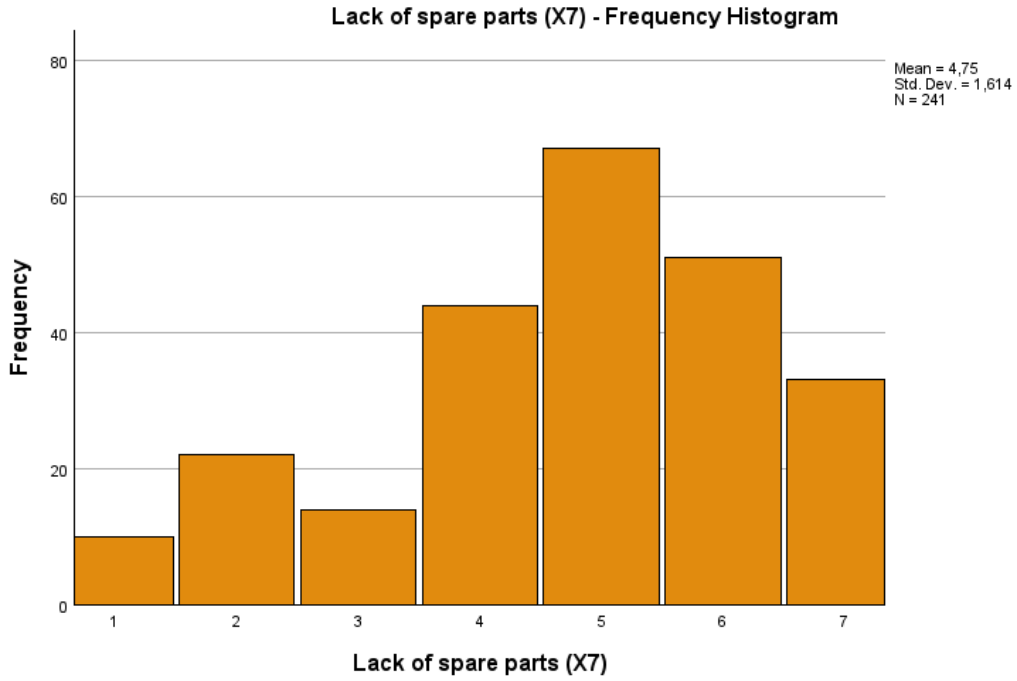
All frequency histograms are made with a 7-Likert scale ranging from "Strongly Disagree" (answer 1) to "Strongly Agree" (answer 7).

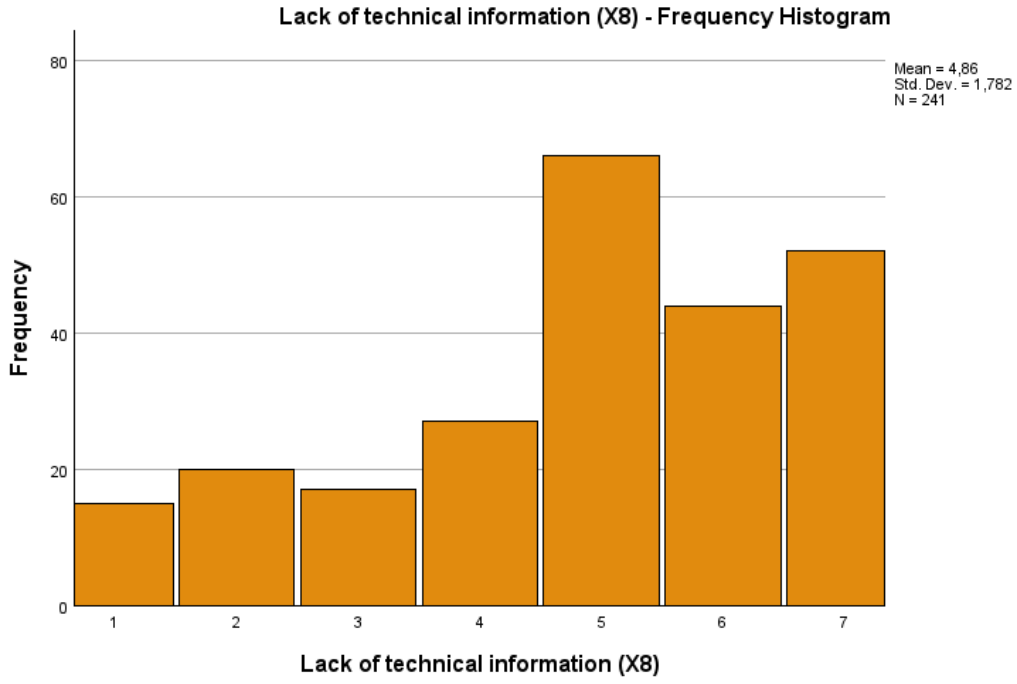


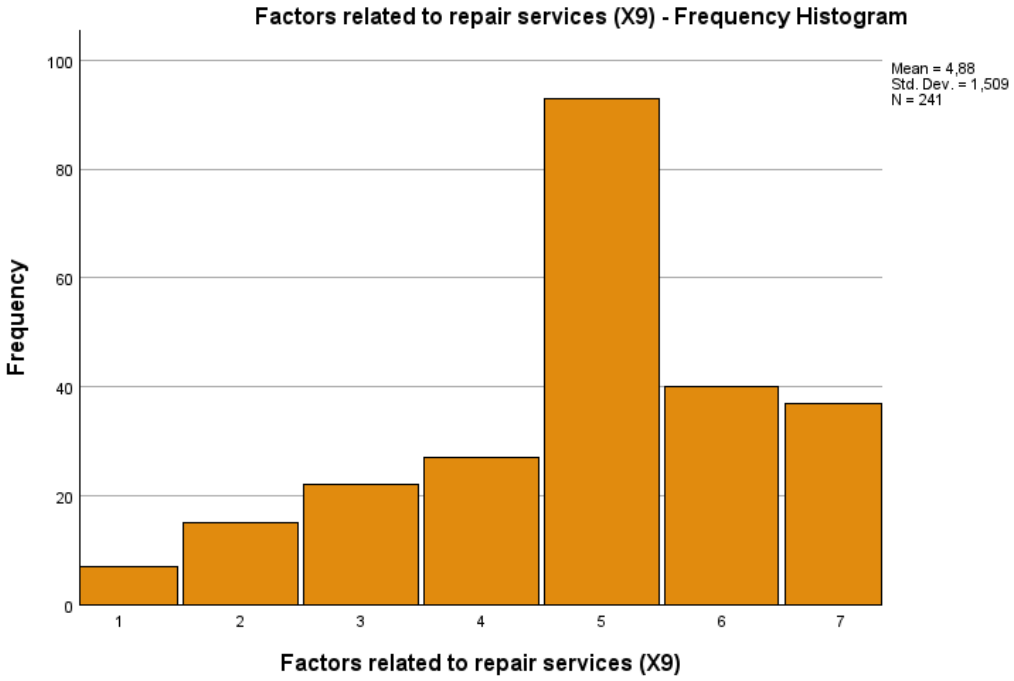


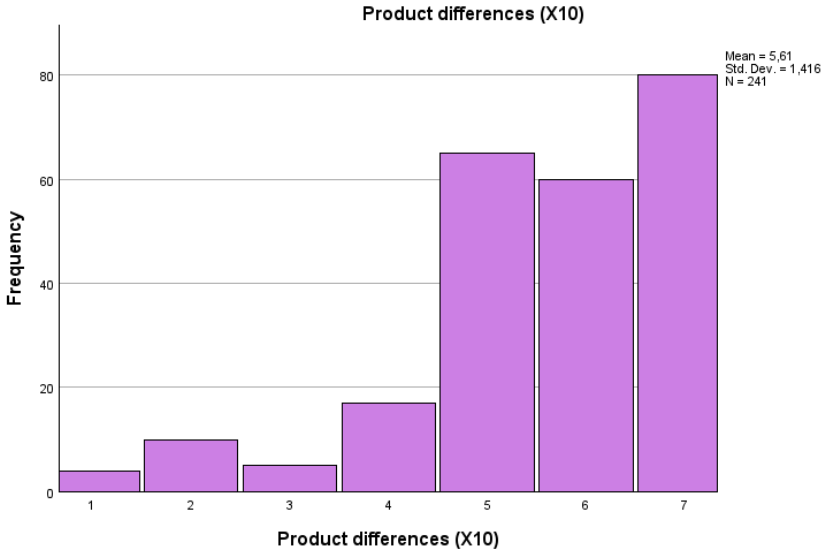

Financial factor (X5) - Frequency Histogram
Mean = 5,46
Std. Dev. = 1,744
N = 241
Frequency
100
80
60
40
20
0
1
2
3
4
5
6
7
Financial factor (X5)


Repair time and efforts (X6) - Frequency Histogram
Mean = 4,44
Std. Dev. = 1,85
N = 241
Frequency
80
60
40
20
0
1
2
3
4
5
6
7
Repair time and efforts (X6)

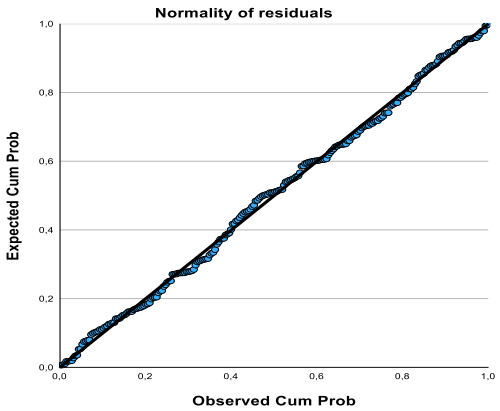

Lack of spare parts (X7) - Frequency Histogram
Mean = 4,75
Std. Dev. = 1,614
N = 241
Frequency
80
60
40
20
0
1
2
3
4
5
6
7
Lack of spare parts (X7)


Lack of technical information (X8) - Frequency Histogram
Mean = 4,86
Std. Dev. = 1,782
N = 241
Frequency
80
60
40
20
0
1
2
3
4
5
6
7
Lack of technical information (X8)


Factors related to repair services (X9) - Frequency Histogram
Mean = 4,88
Std. Dev. = 1,509
N = 241
Frequency
100
80
60
40
20
0
1
2
3
4
5
6
7
Factors related to repair services (X9)


Product differences (X10)
Mean = 5,61
Std. Dev. = 1,416
N = 241
Frequency
80
60
40
20
0
1
2
3
4
5
6
7
Product differences (X10)

Appendix 13 – Normality of residual plot (SPSS)

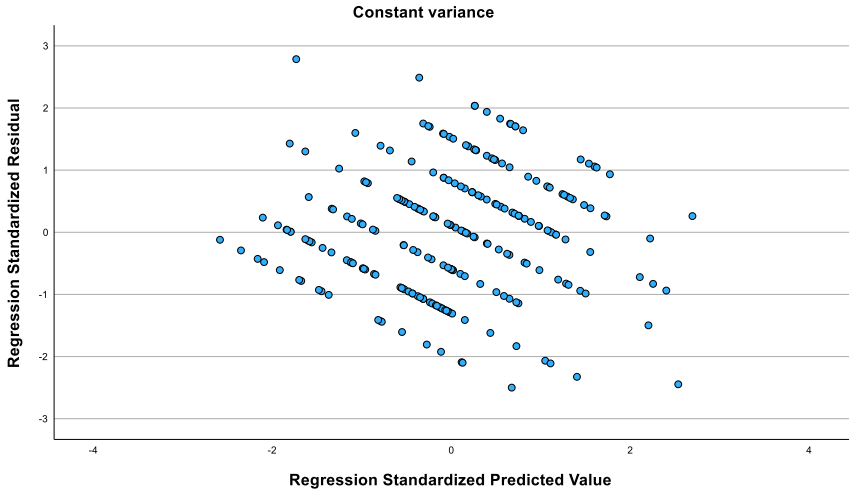


Appendix 14 – Variance Inflation Factor (VIF) table (SPSS)

Variance Inflation Factor (VIF)

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Environmental concerns (X3)	,754	1,326
	Economic attachment (X4)	,767	1,304
	Financial factor (X5)	,887	1,127
	Repair time and efforts (X6)	,623	1,604
	Lack of spare parts (X7)	,576	1,736
	Lack of technical information (X8)	,689	1,452
	Factors related to repair services (X9)	,773	1,294
	Product differences (X10)	,838	1,193

Appendix 15 – Constant Variance plot (SPSS)



Appendix 16 – Anova test p value (regression) (SPSS)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	257,411	8	32,176	16,022	<,001[b]
	Residual	467,932	233	2,008		
	Total	725,343	241			

a. Dependent Variable: Repair propensity (Y)

b. Predictors: (Constant), Product differences (X10), Environmental concerns (X3), Lack of technical information (X8), Financial factor (X5), Factors related to repair services (X9), Economic attachment (X4), Repair time and efforts (X6), Lack of spare parts (X7)

Appendix 17 – Summary model – Adjsuted coefficient of determination (Method 1: Enter) (SPSS)

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	,596[a]	,355	,333	1,417	,355	16,022	8	233	<,001

a. Predictors: (Constant), Product differences (X10), Environmental concerns (X3), Lack of technical information (X8), Financial factor (X5), Factors related to repair services (X9), Economic attachment (X4), Repair time and efforts (X6), Lack of spare parts (X7)

b. Dependent Variable: Repair propensity (Y)

Appendix 18 – Summary model – Adjusted coefficient of determination (Method 2: Stepwise) (SPSS)

Model Summary[d]

					Change Statistics			
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	,584[c]	,341	,332	1,418	,025	9,082	1	238	,003

c. Predictors: (Constant), Economic attachment (X4), Repair time and efforts (X6), Factors related to repair services (X9)

d. Dependent Variable: Repair propensity (Y)

Appendix 19 – Best Regression Model's Excluded Variables (Method 2: Stepwise) (SPSS)

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics: Tolerance	Collinearity Statistics: VIF	Collinearity Statistics: Minimum Tolerance
1	Environmental concerns (X3)	,105[d]	1,782	,076	,115	,783	1,277	,783
	Financial factor (X5)	-,045[d]	-,828	,409	-,054	,941	1,063	,845
	Lack of spare parts (X7)	,031[d]	,487	,627	,032	,689	1,451	,689
	Lack of technical information (X8)	-,041[d]	-,701	,484	-,045	,804	1,244	,804
	Product differences (X10)	-,027[d]	-,487	,627	-,032	,877	1,140	,848

a. Dependent Variable: Repair propensity (Y)

d. Predictors in the Model: (Constant), Economic attachment (X4), Repair time and efforts (X6), Factors related to repair services (X9)

Appendix 20 – Outputs of the Anova 2 tests (SPSS)

Between-Subjects Factors

		Value Label	N
Gender (X1)	1	Female	137
	2	Male	104
Age (X2)	1	18 - 30	139
	2	31 - 45	22
	3	46 - 60	56
	4	> 60	24

Repair propensity (Y)

Descriptive Statistics

Dependent Variable: Repair propensity (Y)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	4,54	1,635	72
	31 - 45	3,15	1,908	13
	46 - 60	3,57	1,803	35
	> 60	3,18	1,510	17
	Total	3,99	1,776	137
Male	18 - 30	3,64	1,694	67
	31 - 45	4,00	1,936	9
	46 - 60	4,00	1,581	21
	> 60	2,43	,976	7
	Total	3,66	1,676	104
Total	18 - 30	4,11	1,718	139
	31 - 45	3,50	1,921	22
	46 - 60	3,73	1,721	56
	> 60	2,96	1,398	24
	Total	3,85	1,738	241

Tests of Between-Subjects Effects

Dependent Variable: Repair propensity (Y)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	68,896[a]	7	9,842	3,497	,001	,095
Intercept	1643,427	1	1643,427	583,960	<,001	,715
Gender (X1)	,281	1	,281	,100	,752	,000
Age (X2)	31,621	3	10,540	3,745	,012	,046
Gender (X1) * Age (X2)	26,499	3	8,833	3,139	,026	,039
Error	655,727	233	2,814			
Total	4298,000	241				
Corrected Total	724,622	240				

a. R Squared = ,095 (Adjusted R Squared = ,068)

Multiple Comparisons

Dependent Variable: Repair propensity (Y)

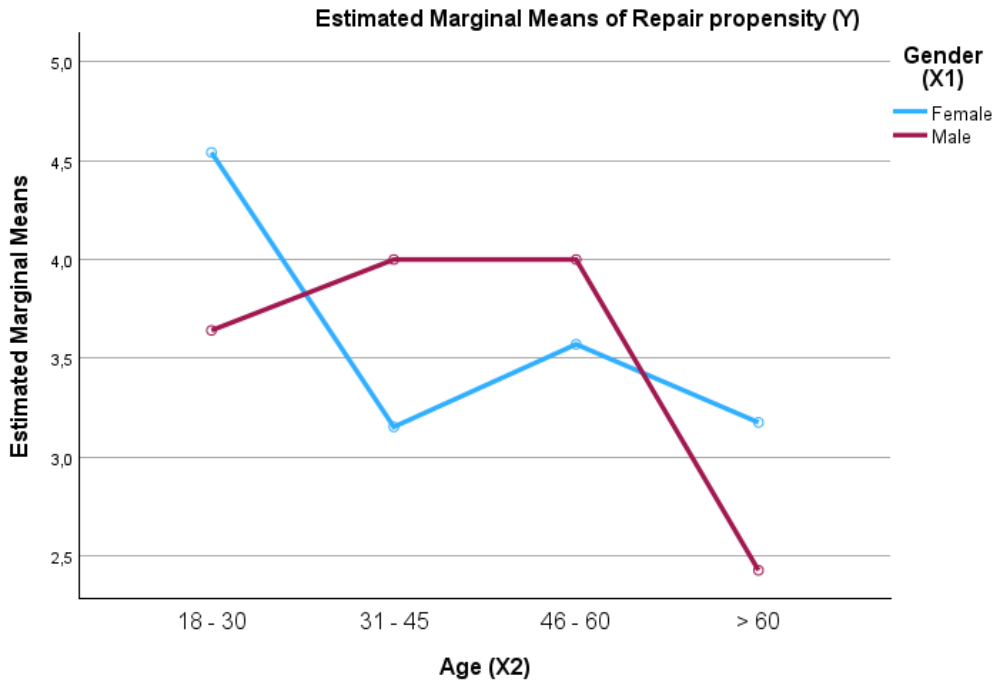
Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	,61	,385	,694
	46 - 60	,38	,266	,950
	> 60	1,15*	,371	,013
31 - 45	18 - 30	-,61	,385	,694
	46 - 60	-,23	,422	1,000
	> 60	,54	,495	1,000
46 - 60	18 - 30	-,38	,266	,950
	31 - 45	,23	,422	1,000
	> 60	,77	,409	,359
> 60	18 - 30	-1,15*	,371	,013
	31 - 45	-,54	,495	1,000
	46 - 60	-,77	,409	,359

Based on observed means.

The error term is Mean Square(Error) = 2,814.

*. The mean difference is significant at the ,05 level.



Environmental Concerns (X_3)

Descriptive Statistics

Dependent Variable: Environmental concerns (X3)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	4,68	1,652	72
	31 - 45	4,08	2,139	13
	46 - 60	4,66	1,955	35
	> 60	5,12	1,166	17
	Total	4,67	1,733	137
Male	18 - 30	3,88	1,919	67
	31 - 45	4,67	1,581	9
	46 - 60	3,86	1,905	21
	> 60	4,00	1,633	7
	Total	3,95	1,861	104
Total	18 - 30	4,29	1,824	139
	31 - 45	4,32	1,912	22
	46 - 60	4,36	1,958	56
	> 60	4,79	1,382	24
	Total	4,36	1,821	241

Tests of Between-Subjects Effects

Dependent Variable: Environmental concerns (X3)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	43,751[a]	7	6,250	1,937	,065	,055
Intercept	2467,198	1	2467,198	764,598	<,001	,766
Gender (X1)	9,152	1	9,152	2,836	,093	,012
Age (X2)	1,574	3	,525	,163	,921	,002
Gender (X1) * Age (X2)	10,189	3	3,396	1,053	,370	,013
Error	751,842	233	3,227			
Total	5379,000	241				
Corrected Total	795,593	240				

a. R Squared = ,055 (Adjusted R Squared = ,027)

Multiple Comparisons

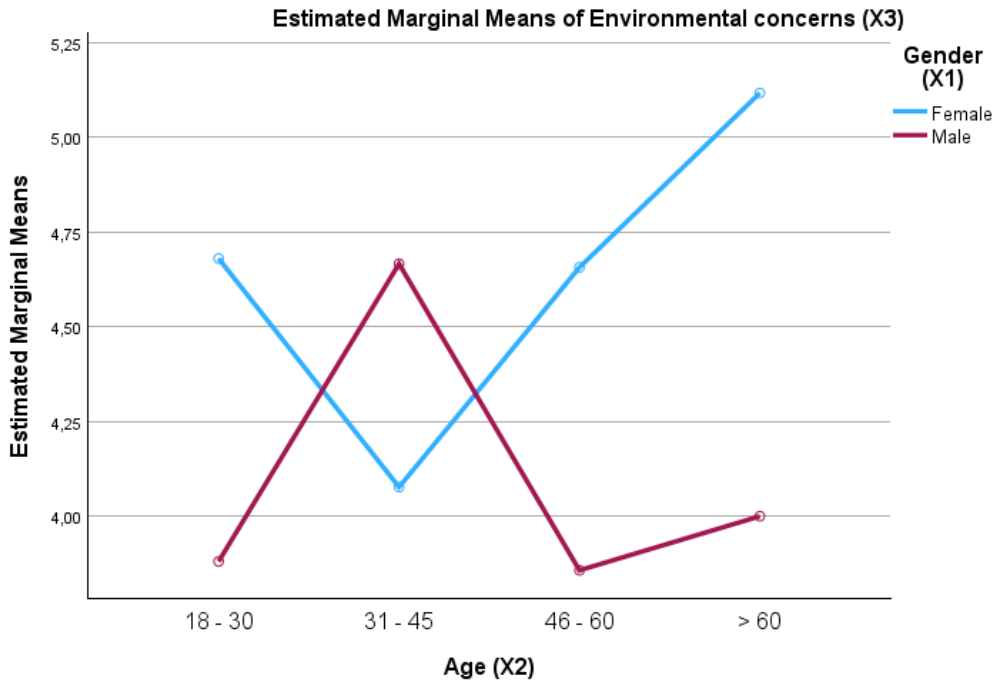
Dependent Variable: Environmental concerns (X3)

Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	-,02	,412	1,000
	46 - 60	-,06	,284	1,000
	> 60	-,50	,397	1,000
31 - 45	18 - 30	,02	,412	1,000
	46 - 60	-,04	,452	1,000
	> 60	-,47	,530	1,000
46 - 60	18 - 30	,06	,284	1,000
	31 - 45	,04	,452	1,000
	> 60	-,43	,438	1,000
> 60	18 - 30	,50	,397	1,000
	31 - 45	,47	,530	1,000
	46 - 60	,43	,438	1,000

Based on observed means.

The error term is Mean Square(Error) = 3,227.



Economic attachment (X_4)

Descriptive Statistics

Dependent Variable: Economic attachment (X4)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	5,15	1,616	72
	31 - 45	3,54	1,266	13
	46 - 60	4,71	1,888	35
	> 60	5,12	1,616	17
	Total	4,88	1,711	137
Male	18 - 30	4,55	1,579	67
	31 - 45	4,33	2,062	9
	46 - 60	4,57	1,690	21
	> 60	3,86	1,215	7
	Total	4,49	1,613	104
Total	18 - 30	4,86	1,621	139
	31 - 45	3,86	1,642	22
	46 - 60	4,66	1,802	56
	> 60	4,75	1,595	24
	Total	4,71	1,677	241

Tests of Between-Subjects Effects

Dependent Variable: Economic attachment (X4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	43,220[a]	7	6,174	2,276	,029	,064
Intercept	2596,043	1	2596,043	957,048	<,001	,804
Gender (X1)	2,955	1	2,955	1,089	,298	,005
Age (X2)	16,694	3	5,565	2,051	,107	,026
Gender (X1) * Age (X2)	13,489	3	4,496	1,658	,177	,021
Error	632,025	233	2,713			
Total	6030,000	241				
Corrected Total	675,245	240				

a. R Squared = ,064 (Adjusted R Squared = ,036)

Multiple Comparisons

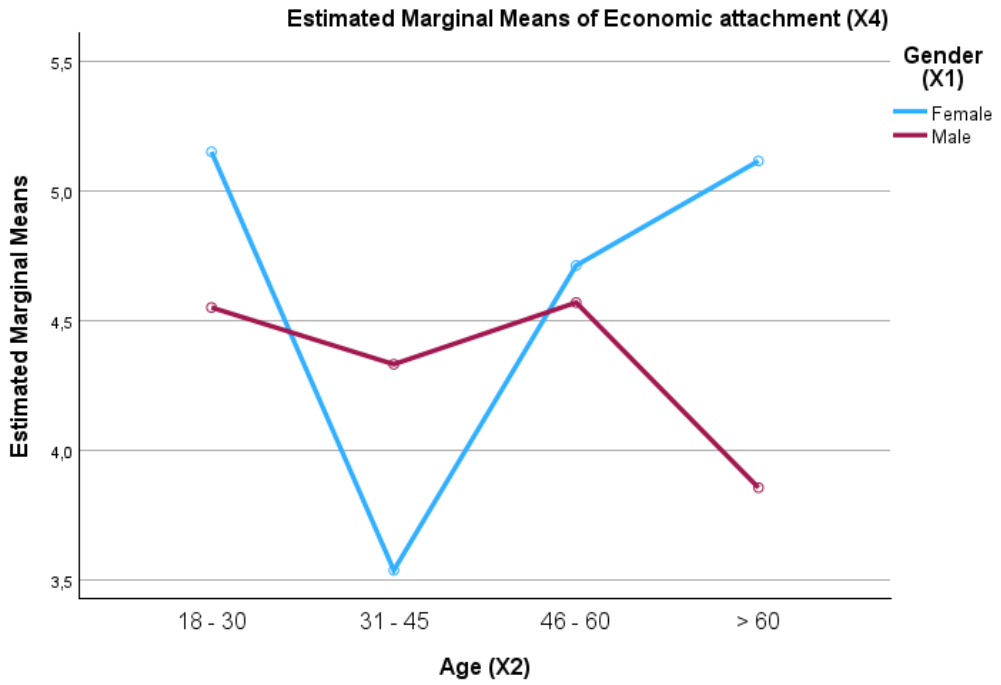
Dependent Variable: Economic attachment (X4)

Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	1,00	,378	,052
	46 - 60	,20	,261	1,000
	> 60	,11	,364	1,000
31 - 45	18 - 30	-1,00	,378	,052
	46 - 60	-,80	,414	,334
	> 60	-,89	,486	,417
46 - 60	18 - 30	-,20	,261	1,000
	31 - 45	,80	,414	,334
	> 60	-,09	,402	1,000
> 60	18 - 30	-,11	,364	1,000
	31 - 45	,89	,486	,417
	46 - 60	,09	,402	1,000

Based on observed means.

The error term is Mean Square(Error) = 2,713.



Financial factor (X_5)

Descriptive Statistics

Dependent Variable: Financial factor (X5)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	5,53	1,491	72
	31 - 45	5,54	1,561	13
	46 - 60	5,23	2,073	35
	> 60	5,47	1,586	17
	Total	5,45	1,662	137
Male	18 - 30	5,57	1,893	67
	31 - 45	4,67	2,398	9
	46 - 60	5,29	1,678	21
	> 60	6,29	,756	7
	Total	5,48	1,854	104
Total	18 - 30	5,55	1,691	139
	31 - 45	5,18	1,943	22
	46 - 60	5,25	1,919	56
	> 60	5,71	1,429	24
	Total	5,46	1,744	241

Tests of Between-Subjects Effects

Dependent Variable: Financial factor (X5)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14,132[a]	7	2,019	,657	,708	,019
Intercept	3837,330	1	3837,330	1249,187	<,001	,843
Gender (X1)	,003	1	,003	,001	,974	,000
Age (X2)	9,388	3	3,129	1,019	,385	,013
Gender (X1) * Age (X2)	7,393	3	2,464	,802	,494	,010
Error	715,744	233	3,072			
Total	7916,000	241				
Corrected Total	729,876	240				

a. R Squared = ,019 (Adjusted R Squared = -,010)

Multiple Comparisons

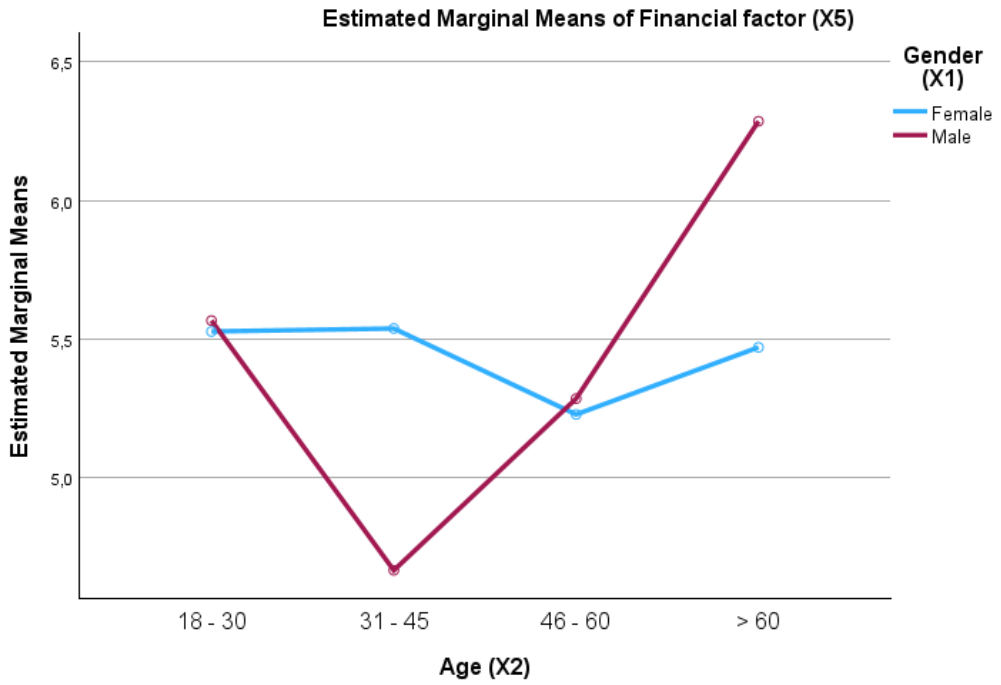
Dependent Variable: Financial factor (X5)

Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	,36	,402	1,000
	46 - 60	,30	,277	1,000
	> 60	-,16	,387	1,000
31 - 45	18 - 30	-,36	,402	1,000
	46 - 60	-,07	,441	1,000
	> 60	-,53	,517	1,000
46 - 60	18 - 30	-,30	,277	1,000
	31 - 45	,07	,441	1,000
	> 60	-,46	,428	1,000
> 60	18 - 30	,16	,387	1,000
	31 - 45	,53	,517	1,000
	46 - 60	,46	,428	1,000

Based on observed means.

The error term is Mean Square(Error) = 3,072.



Repair Time and efforts (X_6)

Descriptive Statistics

Dependent Variable: Repair time and efforts (X6)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	3,88	1,719	72
	31 - 45	5,54	1,050	13
	46 - 60	4,23	1,926	35
	> 60	5,65	1,272	17
	Total	4,34	1,796	137
Male	18 - 30	4,49	1,862	67
	31 - 45	4,67	1,658	9
	46 - 60	4,29	2,327	21
	> 60	6,00	,816	7
	Total	4,57	1,920	104
Total	18 - 30	4,17	1,810	139
	31 - 45	5,18	1,368	22
	46 - 60	4,25	2,065	56
	> 60	5,75	1,152	24
	Total	4,44	1,850	241

Tests of Between-Subjects Effects

Dependent Variable: Repair time and efforts (X6)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	83,186[a]	7	11,884	3,751	<,001	,101
Intercept	3032,675	1	3032,675	957,222	<,001	,804
Gender (X1)	,049	1	,049	,015	,901	,000
Age (X2)	58,115	3	19,372	6,114	<,001	,073
Gender (X1) * Age (X2)	11,530	3	3,843	1,213	,306	,015
Error	738,192	233	3,168			
Total	5572,000	241				
Corrected Total	821,378	240				

a. R Squared = ,101 (Adjusted R Squared = ,074)

Multiple Comparisons

Dependent Variable: Repair time and efforts (X6)

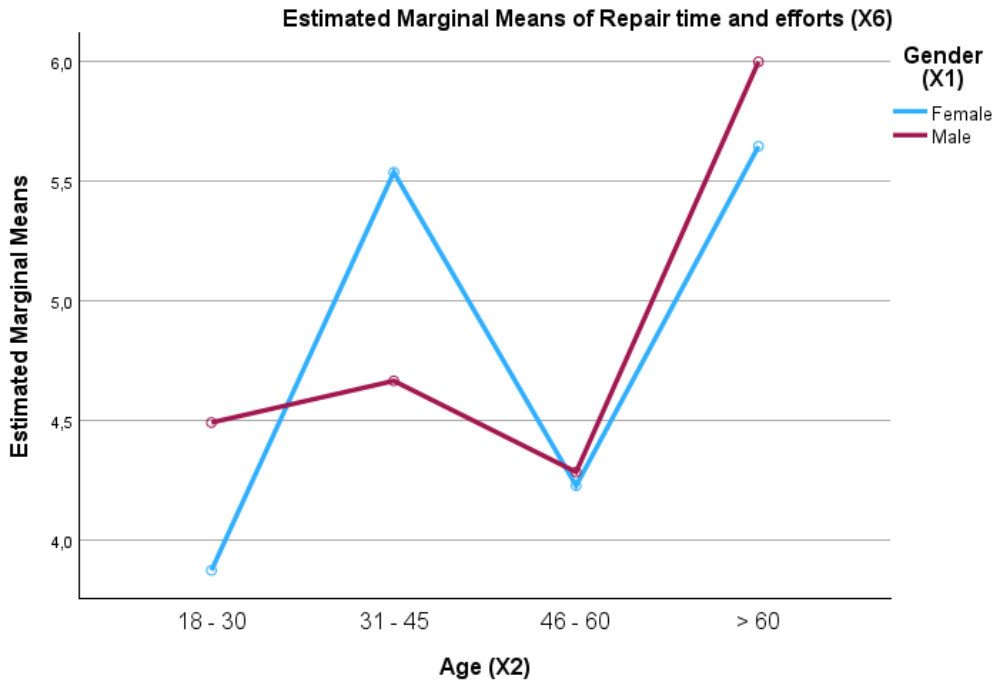
Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	-1,01	,408	,085
	46 - 60	-,08	,282	1,000
	> 60	-1,58*	,393	<,001
31 - 45	18 - 30	1,01	,408	,085
	46 - 60	,93	,448	,231
	> 60	-,57	,525	1,000
46 - 60	18 - 30	,08	,282	1,000
	31 - 45	-,93	,448	,231
	> 60	-1,50*	,434	,004
> 60	18 - 30	1,58*	,393	<,001
	31 - 45	,57	,525	1,000
	46 - 60	1,50*	,434	,004

Based on observed means.

The error term is Mean Square(Error) = 3,168.

*. The mean difference is significant at the ,05 level.



Lack of Spare parts (X_7)

Descriptive Statistics

Dependent Variable: Lack of spare parts (X7)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	4,44	1,626	72
	31 - 45	5,77	,832	13
	46 - 60	4,69	1,811	35
	> 60	4,88	1,495	17
	Total	4,69	1,635	137
Male	18 - 30	4,78	1,506	67
	31 - 45	4,78	1,856	9
	46 - 60	4,57	1,832	21
	> 60	6,14	,690	7
	Total	4,83	1,591	104
Total	18 - 30	4,60	1,572	139
	31 - 45	5,36	1,399	22
	46 - 60	4,64	1,803	56
	> 60	5,25	1,422	24
	Total	4,75	1,614	241

Tests of Between-Subjects Effects

Dependent Variable: Lack of spare parts (X7)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	34,970[a]	7	4,996	1,971	,060	,056
Intercept	3242,234	1	3242,234	1279,128	<,001	,846
Gender (X1)	,478	1	,478	,189	,664	,001
Age (X2)	20,847	3	6,949	2,742	,044	,034
Gender (X1) * Age (X2)	15,017	3	5,006	1,975	,118	,025
Error	590,590	233	2,535			
Total	6056,000	241				
Corrected Total	625,560	240				

a. R Squared = ,056 (Adjusted R Squared = ,028)

Multiple Comparisons

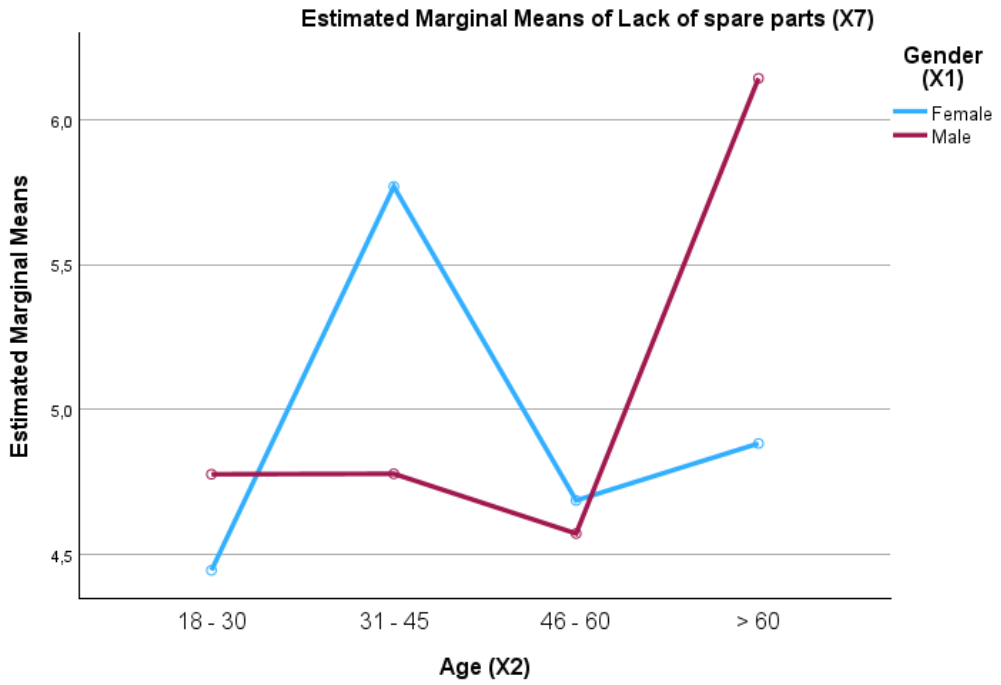
Dependent Variable: Lack of spare parts (X7)

Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	-,76	,365	,233
	46 - 60	-,04	,252	1,000
	> 60	-,65	,352	,407
31 - 45	18 - 30	,76	,365	,233
	46 - 60	,72	,401	,440
	> 60	,11	,470	1,000
46 - 60	18 - 30	,04	,252	1,000
	31 - 45	-,72	,401	,440
	> 60	-,61	,388	,716
> 60	18 - 30	,65	,352	,407
	31 - 45	-,11	,470	1,000
	46 - 60	,61	,388	,716

Based on observed means.

The error term is Mean Square(Error) = 2,535.



Lack of technical information (X_8)

Descriptive Statistics

Dependent Variable: Lack of technical information (X8)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	4,79	1,592	72
	31 - 45	5,31	1,932	13
	46 - 60	4,54	1,900	35
	> 60	5,59	1,417	17
	Total	4,88	1,704	137
Male	18 - 30	4,75	1,902	67
	31 - 45	4,56	1,810	9
	46 - 60	5,19	2,040	21
	> 60	5,14	1,574	7
	Total	4,85	1,889	104
Total	18 - 30	4,77	1,742	139
	31 - 45	5,00	1,877	22
	46 - 60	4,79	1,961	56
	> 60	5,46	1,444	24
	Total	4,86	1,782	241

Tests of Between-Subjects Effects

Dependent Variable: Lack of technical information (X8)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	20,030[a]	7	2,861	,898	,509	,026
Intercept	3212,460	1	3212,460	1008,151	<,001	,812
Gender (X1)	,716	1	,716	,225	,636	,001
Age (X2)	6,328	3	2,109	,662	,576	,008
Gender (X1) * Age (X2)	9,560	3	3,187	1,000	,394	,013
Error	742,452	233	3,186			
Total	6462,000	241				
Corrected Total	762,481	240				

a. R Squared = ,026 (Adjusted R Squared = -,003)

Multiple Comparisons

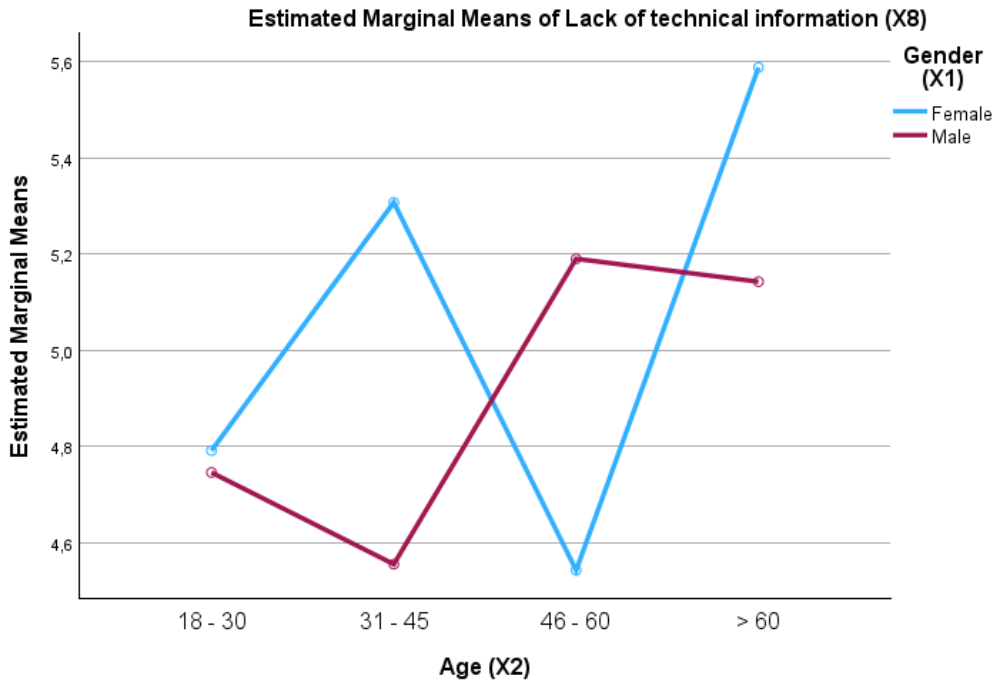
Dependent Variable: Lack of technical information (X8)

Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	-,23	,410	1,000
	46 - 60	-,02	,283	1,000
	> 60	-,69	,395	,494
31 - 45	18 - 30	,23	,410	1,000
	46 - 60	,21	,449	1,000
	> 60	-,46	,527	1,000
46 - 60	18 - 30	,02	,283	1,000
	31 - 45	-,21	,449	1,000
	> 60	-,67	,436	,743
> 60	18 - 30	,69	,395	,494
	31 - 45	,46	,527	1,000
	46 - 60	,67	,436	,743

Based on observed means.

The error term is Mean Square(Error) = 3,186.



Factors related to repair services (X_9)

Descriptive Statistics

Dependent Variable: Factors related to repair services (X9)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	4,89	1,379	72
	31 - 45	5,54	1,050	13
	46 - 60	4,23	1,816	35
	> 60	4,76	1,786	17
	Total	4,77	1,559	137
Male	18 - 30	5,12	1,332	67
	31 - 45	4,44	1,236	9
	46 - 60	4,86	1,905	21
	> 60	5,29	,951	7
	Total	5,02	1,435	104
Total	18 - 30	5,00	1,357	139
	31 - 45	5,09	1,231	22
	46 - 60	4,46	1,858	56
	> 60	4,92	1,586	24
	Total	4,88	1,509	241

Tests of Between-Subjects Effects

Dependent Variable: Factors related to repair services (X9)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	27,426[a]	7	3,918	1,760	,096	,050
Intercept	3094,577	1	3094,577	1389,711	<,001	,856
Gender (X1)	,165	1	,165	,074	,785	,000
Age (X2)	8,691	3	2,897	1,301	,275	,016
Gender (X1) * Age (X2)	11,826	3	3,942	1,770	,154	,022
Error	518,839	233	2,227			
Total	6275,000	241				
Corrected Total	546,266	240				

a. R Squared = ,050 (Adjusted R Squared = ,022)

Multiple Comparisons

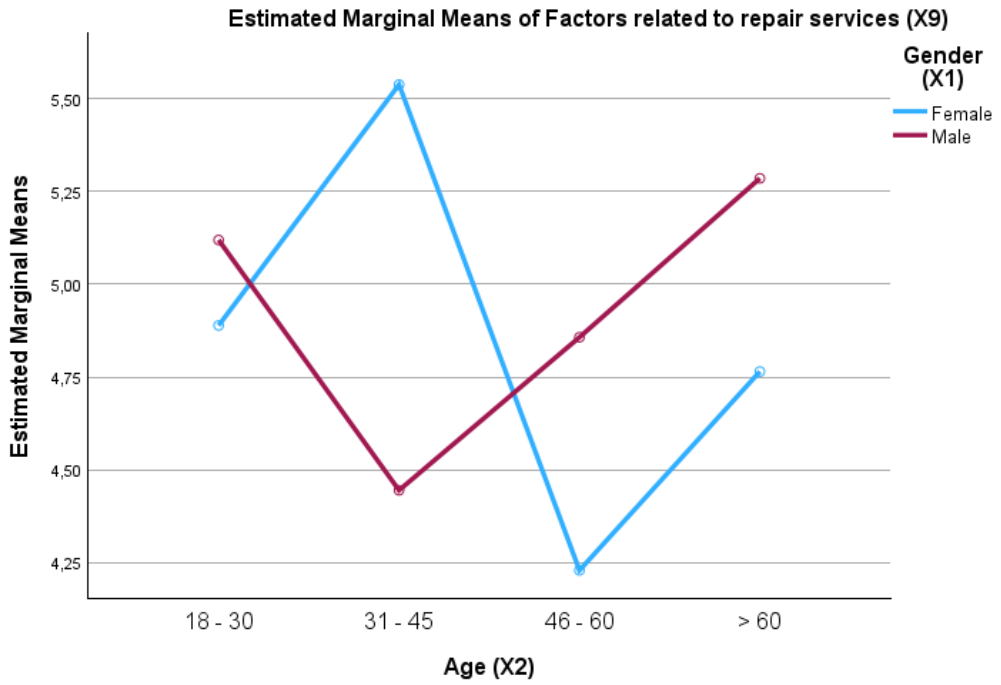
Dependent Variable: Factors related to repair services (X9)

Bonferroni

(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	-,09	,342	1,000
	46 - 60	,54	,236	,145
	> 60	,08	,330	1,000
31 - 45	18 - 30	,09	,342	1,000
	46 - 60	,63	,375	,579
	> 60	,17	,440	1,000
46 - 60	18 - 30	-,54	,236	,145
	31 - 45	-,63	,375	,579
	> 60	-,45	,364	1,000
> 60	18 - 30	-,08	,330	1,000
	31 - 45	-,17	,440	1,000
	46 - 60	,45	,364	1,000

Based on observed means.

The error term is Mean Square(Error) = 2,227.



Product differences (X_{10})

Descriptive Statistics

Dependent Variable: Product differences (X10)

Gender (X1)	Age (X2)	Mean	Std. Deviation	N
Female	18 - 30	5,68	1,309	72
	31 - 45	6,08	1,038	13
	46 - 60	5,23	1,555	35
	> 60	5,94	1,197	17
	Total	5,64	1,355	137
Male	18 - 30	5,61	1,477	67
	31 - 45	5,11	1,453	9
	46 - 60	5,52	1,721	21
	> 60	6,00	1,155	7
	Total	5,58	1,499	104
Total	18 - 30	5,65	1,388	139
	31 - 45	5,68	1,287	22
	46 - 60	5,34	1,610	56
	> 60	5,96	1,160	24
	Total	5,61	1,416	241

Tests of Between-Subjects Effects

Dependent Variable: Product differences (X10)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13,610[a]	7	1,944	,969	,455	,028
Intercept	4124,959	1	4124,959	2054,869	<,001	,898
Gender (X1)	,936	1	,936	,466	,495	,002
Age (X2)	5,636	3	1,879	,936	,424	,012
Gender (X1) * Age (X2)	6,092	3	2,031	1,012	,388	,013
Error	467,726	233	2,007			
Total	8066,000	241				
Corrected Total	481,336	240				

a. R Squared = ,028 (Adjusted R Squared = -,001)

Multiple Comparisons

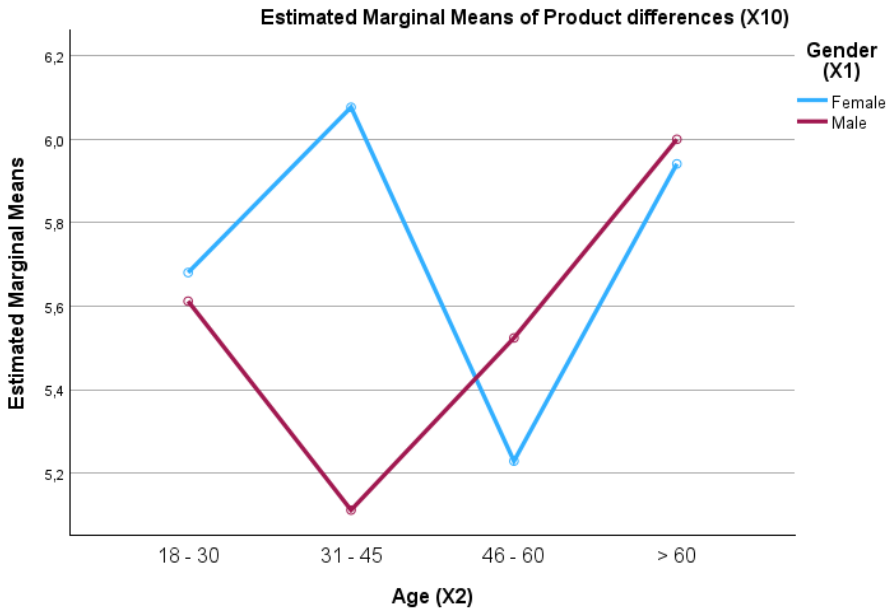
Dependent Variable: Product differences (X10)

Bonferroni

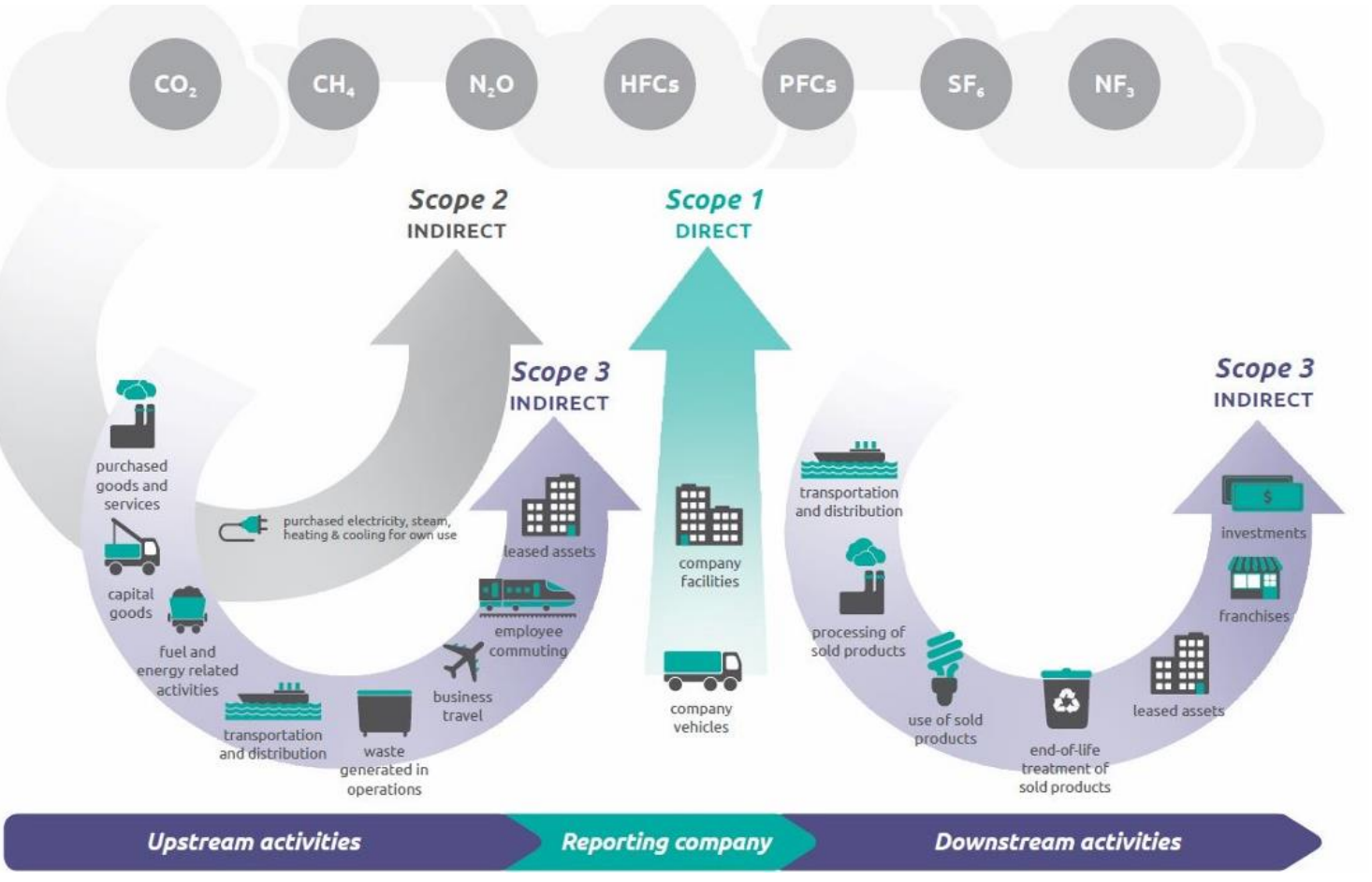
(I) Age (X2)	(J) Age (X2)	Mean Difference (I-J)	Std. Error	Sig.
18 - 30	31 - 45	-,03	,325	1,000
	46 - 60	,31	,224	1,000
	> 60	-,31	,313	1,000
31 - 45	18 - 30	,03	,325	1,000
	46 - 60	,34	,357	1,000
	> 60	-,28	,418	1,000
46 - 60	18 - 30	-,31	,224	1,000
	31 - 45	-,34	,357	1,000
	> 60	-,62	,346	,448
> 60	18 - 30	,31	,313	1,000
	31 - 45	,28	,418	1,000
	46 - 60	,62	,346	,448

Based on observed means.

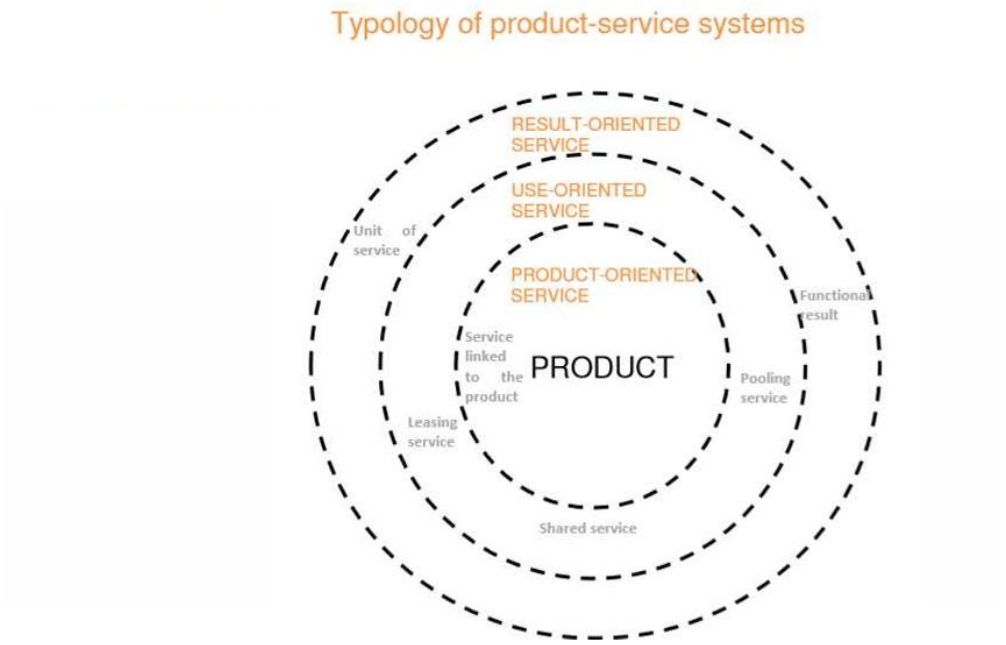
The error term is Mean Square(Error) = 2,007.



Appendix 21 – Science Based targets – CO2 emissions measurement with Scope 1, 2 and 3 (Marichal, 2023)



Appendix 22 – Product Service System: Typology (Mossay, 2023)



Source : TRANSITIONING TO FUNCTIONAL ECONOMY AND PRODUCT-SERVICE SYSTEMS IN AN URBAN CONTEXT– MARCH 2014