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Towards More Repair of Mobile Phones in Spain

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Abstract

Addressing electronic waste is crucial for meeting the environmental needs of the 21st Century, as WEEE is one of the fastest growing waste streams. Spain has emerged as one of the top countries globally for per capita mobile phone consumption. For this reason, this thesis focuses on European and Spanish initiatives that am to improve the circularity of mobile phones through repair. In recent years, , consumer repairs, particularly for independent repairers, have faced many barriers created by producers. Circular Economy strategies at the EU and national levels aim to prevent waste through methods known as "slowing" and "closing" of "loops", both of which would benefit the repair sector, and independent repairers in particular.

With this background, the central research question of this thesis was derived, namely: *How do the recent regulations and policies that are currently implemented, and those that are expected, influence the independent repair sector?* While a variety of policies and directives were examined in the literature review, the emphasis was placed on the provisions regarding mobile phones. In addition to this desk research, the author conducted thirteen in-person interviews with independent repairers in two cities in Spain. Finally, a qualitative analysis produced a number of conclusions and policy recommendations to improve rates of repair and benefit the independent repairers sector.

In conclusion, access to repair needs to be easier, faster, and more accessible. Thus, policymakers and producers need to provide more support to independent repairers to improve access to repair in this way. Further up the supply chain, legal initiatives such as the EU Ecodesign Directive can benefit repairers by regulating the design of products to be more durable and more repairable. Therefore, a diverse policy mix is necessary to address all the areas of repair through the product's lifecycle and thus, prevent e-waste.

Keywords: e-waste, repairers, Spain, Ecodesign, Circular Economy

Executive Summary

Context

Understanding and addressing the environmental impacts of WEEE is a key aspect for policymakers as these products are the fastest growing waste stream in recent years. In Spain, for example, Dorado (2018) found that there are more mobile phone numbers than residents. To prevent these devices, and the strategic materials contained within them, from being wasted and disposed of, improving access to repair is critical. However, independent repairers have traditionally faced many barriers, often stemming from producers, ranging from lack of spare part availability to programmed obsolescence, and this also affects the consumers. Circular Economy strategies, included in several European and Spanish policies and regulations, aim to prevent waste through methods known as "slowing" (e.g., by extending product lifespans) and "closing" (e.g., by reusing and preparing for reuse) of "loops", which would benefit the repair sector, and the independent repairers in particular.

Methodology

With this scope, a central research question emerged, along with three sub-questions:

1. How do the recent regulations and policies that are currently implemented, and those that are expected in the near future, influence the independent repairers sector?
2. What policies can be implemented in the independent repair sector in Spain in order to benefit this sector?
3. What is the attitude of the repairers toward the new proposals?
4. What is the current situation of the independent repair sector in Spain?

This qualitative research began with a literature review examining the primary causes of repair and disposal, recent policies and amendments that influence repair and repairability (e.g., the French Repairability Index and the EU Ecodesign Directive) and the role that each stakeholder group can play in advancing the repair of mobile phones. To provide valuable experiential insights, thirteen independent repairers were interviewed in person in two major cities in Spain: Barcelona and Madrid. The results of these interviews were analyzed qualitatively to identify key themes. These findings produced policy recommendations for improving rates of repair in mobile phones.

Findings

<u>RQ1: How do the recent regulations and policies that are currently implemented, and those that are expected, influence the independent repairers sector?</u>
Since 2015, many new policies and strategies have emerged in the EU that promote the Circular Economy. These proposals often prioritize the prevention of waste and have identified small ICT (including mobile phones) as one of the sectors that requires urgent action. This is in part because mobile phones contain many strategic materials, including rare earth metals, which have a significant environmental impact from production, including high greenhouse gas emissions from extracting and exploiting these resources. Circular Economy legislation, by promoting waste prevention activities, will necessarily benefit the repair sector.

The use of mobile phones has been growing in recent decades, which is particularly problematic because small ICT have some of the lowest rates of collection, often due to the so-called "treasure effect", wherein consumers store their device at home after its useful life to preserve the data stored within its memory. For these reasons, mobile phones are often outlined explicitly as priorities for ecodesign initiatives. Many of these ecodesign policies and directives will

improve the repairability of mobile phones through mandating design for durability, modularity, and disassembly, among others.

As mentioned above, many different policies contain objectives and provisions that affect the repair of mobile phones. For example, the Repairability Index, which was approved by the Spanish government within the last year (2022) contains criteria on documentation, disassembly, availability of spare parts, and other, product-specific aspects. Other policy instruments, such as fiscal incentives, by means of tax reductions and subsidies, can further promote repair. A well-designed policy mix is crucial to address all stages of the lifecycle of EEE, from Pre-market Producer Responsibility (PPR) in production to Extended Producer Responsibility (EPR) in waste management.

Spain's *Action Plan for the Circular Economy* (2021) describes many of the proposed initiatives to improve circularity, and therefore, repair. For example, some provisions would extend the product warranty and availability of spare parts. Other current legislation also supports these objectives, including the *Law on Wastes and Contaminated Soils* (2022), which contains requirements for design and targets for reuse of these products. Therefore, this legislation would greatly benefit repairers by promoting (and even mandating) circular activities.

RQ1.1: What policies can be implemented in order to support the independent repairers sector in Spain?

Further expansion of the repair networks and associations would improve the distribution of information and the quality of repairs. In Austria, for example, these groups benefit (independent) repairers by including them in the Repair Voucher system and by facilitating access to spare parts (Almén et al., 2021). Such networks could support and enhance the repair sector in Spain. Additionally, fiscal incentives, such as the VAT reduction in Sweden (Milios, 2021), were supported amongst the independent repairers interviewed for this study. This is an area that is severely lacking in the Spanish context. Finally, it is crucial to change consumer attitudes toward reuse and repair. Certification of repairers or of secondhand products can guarantee quality to consumers. Furthermore, such a certification scheme would allow independent repairers access to information from official sources and even grow their customer base. However, this proposal is still in its infancy, as none of the repairers interviewed held Spanish certifications.

RQ1.2: What is the attitude of the repairers toward the new proposals?
In short, virtually none of the repairers interviewed were aware of the current policy landscape, but, upon learning more, all were in support of the initiatives. It can be assumed that consumers would not be any more aware of this context than those working in the field.

RQ1.3: What is the current situation of the independent repairers' sector in Spain?
Independent repairers tend to be divided into two categories: those who perform the simple, more common repairs, and those "technicians" who can perform more complex repairs. In general, the repairers interviewed stated that the information for the most common repairs is freely and easily accessible online, and thus access to information was not a major barrier for their operations. However, intellectual property and the legal ramifications it poses are a limiting factor for many repairers. Opinion was divided among the respondents on whether or not access to spare parts and tools was a major issue due to the fact that was mentioned that they were able to find not official (non-original) tools, so called Chinese tools. Finally, cost was identified (in the literature and in the interviews) as a deciding factor for many consumers on whether or not to repair. The independent repair sector generally has the competitive advantage over official repairers in this regard, but the repair sector as a whole is not very competitive.

Recommendations

1. Introduce repair vouchers

Consumers receive by the municipality a set amount to spend each year on electronics repairs, which benefits independent repairers by expanding their customers and improving consumers attitudes toward repairs. Repair vouchers have already been successfully implemented in Austria (Almén et al., 2021).

2. Repair networks

Associations can support repair activities through means of knowledge-sharing and providing access to platforms and other initiatives, such as the repair voucher system. Currently, repairer networks in Spain are largely on a one-to-one basis through agreements between individual practitioners.

3. Implement fiscal incentives

Fiscal incentives are, of course, widely supported by independent repairers in Spain, but no current systems are in place in the country. Sweden, for its part, has established a reduced VAT for repairers (Milios, 2021) and a similar system could be implemented in Spain. These types of fiscal incentives (along with the repair vouchers mentioned above) would make repair less costly and thus more accessible and attractive to consumers.

4. Support second hand

Repairing and reselling secondhand products can be a profitable revenue stream for many independent repairers. However, to facilitate this process, the government needs to implement "closing the loops" Circular Economy strategies which prioritize reuse and preparation reuse as the preferred waste management strategies outlined under the waste hierarchy.

5. Introduce a certification system for repairers

The final policy recommendation derived from this research process is the promotion of a certification system for repairers. This certification would improve consumer confidence in repair services and secondhand products. Additionally, the certification can allow independent repairers better access to official spare parts and information.

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Abbreviations

CE – Circular Economy

EEE – Electrical and Electronic Equipment

EOL – End-Of-Life

EPR – Extended Producer Responsibility

EU – European Union

GDP – Gross Domestic Product

ICT – Information and Computing Technologies

LEV – Light Electric Vehicle

LIV – Lithium-Ion Battery

MIC – Ministry of Consumption

OEM – Original Equipment Manufacturer

PPR – Pre-market Producer Responsibility

PRO/SCRAP – Producer Responsibility Organization

R2R – Right to Repair (Movement)

VAT – Value Added Tax

WARM – Waste Reduction Model

WEEE – Waste of Electrical and Electronic Equipment

WTP – Willingness to Pay

1 Introduction

Currently, people depend on different types of Electrical and Electronic Equipment (EEE) as we live in a technologic era. On the one hand, this equipment facilitates our daily lives and has become necessary for day-to-day activities, such as work, entertainment, education, and communications, among many others. On the other hand, significant issues can begin in the production phase of the EEE, with the pollution and environmental impacts caused by the extraction of raw materials, and continue into the use phase, concluding with the end-of-life stage of devices.

The problem is that the amount of Waste of Electrical and Electronic Equipment (WEEE) produced has grown each year with increasing speed as it is reported by Forti et al. (2020) in the *Global E-Waste Monitor 2020*. This stream of waste is increasing 3% annually as a consequence of business strategies and models in which multiple upgrades are planned by the producers (Yu, Yu & Tan, 2020) in a very short time, aiming to innovate the market and, of course, generate more revenue. With these devices being very common, daily lives are constantly being changed as the electronics sector develops. This sector is expected to produce 14% of the total carbon emissions through the lifecycle of EEE (PACE, 2019).

Forti et al. (2021) conclude that recycling is not enough to address the e-waste issue as, for instance, in 2019 just 17.4% was collected, whereas the rest was not. The global e-waste generated per capita has increased from 6.4kg in 2014, to 7.8kg in 2022 and with projections to reach 9.0kg globally, but in Europe the generation per capita has long surpassed even 9kg, at 16.2kg per person, and this number is not expected to stop increasing naturally.

In 2020, it was reported in the UN Global E-Waste Monitor for 2019 that 53.6 million metric tons of e-waste were generated globally and there is a projection considering 74 metric tons by 2030. This figure could be almost doubled (120 million tons) by 2050 if nothing is done to mitigate this situation (PACE, 2019).

For many years, many conversations about e-waste and solution(s) were intended to deal with its collection, management and recycling of the raw materials. Other debates focused on reducing illegal dumping in lower income countries in order to avoid harm to the environment and the population from the potentially hazardous waste. The EU was the first to focus on this stream of waste, due to the introduction of the WEEE Directive in 2002. Since then, little attention was given to the design phase (Bressanelli et al., 2020). However, recently the main focus is on the prevention of waste, which can be achieved through designing for durability or easy repairability.

In addition, the covid-19 pandemic increased the demand of EEE (Yu, Yu, & Tan, 2020) and accelerated the digital era, which necessarily needs functional EEE to develop certain activities as that have emerged such as home office jobs. Technology has achieved the dematerialization of many other EEE (PACE, 2019), for instance, all devices intended to reproduce music. Yet, that has caused other problems. For instance, in 2019 it was forecasted that within the next year, the number of devices connected to the internet was going to be almost triple the number of humans on earth (PACE, 2019).

Multiple studies have explored proposals to manage with e-waste, such as human-robot collaboration (Renteria et al., 2019), the social benefits of WEEE re-use, (González et al., 2017), evaluation of sites for WEEE collection and recycle (Queiruga et al., 2008), urban mining (Talens et al., 2020), source reduction, recycling landfilling, and combustion (though the last two are the less preferable) (US EPA, 2019), taking advantage of the metabolic activity of certain

microorganisms (Dorado, 2018), or attachment factors in small household electronics (Mulet, 2020; Mulet, 2022).

According to research carried out in the report named *A new circular vision for electronics, time for a global reboot* developed by PACE (2021) in order to achieve a zero-waste economy, the system has to be upgraded to reach a Circular Economy (CE) and thus several actions have to be implemented, such as paying closer attention to the design of products. Further, prolonged lifetime – and associated strategies like increasing the number of consumer repairs – are needed to reduce the life cycle environmental impacts of EEE.

Since the European Union has the highest e-waste production per capita, it can be assumed that the EEE purchases per capita is also high. In addition, European citizens have great purchasing power which can lead to reduced incentives to repair broken product; instead, consumers purchase new ones. The fast development of technology and the interest in innovation have led producers to develop electronics that have many features and functions. Hence, the composition and the design of the products have been evolving to be increasingly complex, making repair of broken devices difficult if not impossible (Jin, Yang, & Zhu, 2021).

1.1 Problem Identification

To reduce waste production, the Circular Economy offers a meaningful solution, as an alternative economic model. (Svensson et al., 2021). In the first EU Circular Economy Action Plan (2015) the durability and repairability of products was established as a requirement in the production phase and has been progressing with time from a voluntary scheme to a mandatory one. In 2020, a new Circular Economy Action Plan was published in which the need to produce durable and repairable goods is emphasized. Therefore, the main objectives are intended to make sustainable products the norm, empower consumers, and ensure less waste, among others. EU actions to promote repairs are derived primarily from its aim of transitioning toward a more Circular Economy (Pihlajarinne, 2020).

In the words of Svensson et al. (2018), "*Waste management and CE strategies have the potential to address e-waste critical materials, and larger resource efficiency issues by not only narrowing and closing the material loops through Ecodesign and recycling but also slowing material loops through longer-lasting products and repair*". As it is well known among environmentalists, *"the best wastes are those that are not produced"*. Recycling and source reduction (repair, refurbishment, second hand) are some of the best strategies to manage e-waste, since both have the potential to impact the production upstream (US EPA, 2019).

Therefore, repair activities are a key aspect of achieving the expected environmental objectives and reducing the impact of the electronics industry. Several barriers limit the access to repair, which in turn, discourages consumers from repair and benefits the producers. Those barriers can be encompassed in 4 groups: 1) technical, 2) administrative, 3) economic, and 4) social and cultural barriers (Almén et al., 2021). Moreover, the scholars that have carried out research about the barriers have reached similar conclusions. Some examples of barriers to repairing electronics are conditioned sales contracts, design measures, patent and copyright law, limited access to spare parts, limited access to manuals and information for repair, and the necessity of special tools to open and repair the electronics (Svensson, 2018). The problem is that those barriers make repair expensive and not accessible for consumers, and consequently, they prefer to replace the items.

When talking about repair services, there are either *"open"* or *"closed"* access to repair services, where in the former, customers can decide who will perform the repair services, and in the latter,

the customers can access only access repair that the producer offers, by repair services in its "authorized networks" (Svensson et al., 2018). The market has suffered from monopolies carried out by companies, and hence a new positive and transparent repairability has to be implemented (Hernandez, 2020). Open access is convenient for consumers and benefits independent repairers, which is precisely what the new regulations and movements are intended to achieve.

Currently, the Right-to-Repair movement seeks to eliminate barriers to repair that have been imposed on consumers and independent repairers. This movement started in the US, and generally adopted that name R2R. This movement began to gain strength in 2014, when the first successful bill of that considered repair, as passed in South Dakota, USA (Hatta, 2020), and when the automobile Original Equipment Manufacturers (OEMs) reached a nationwide agreement with independent car repairers in order to provide spare parts and tools in a fair and reasonable way (Svensson et al., 2018). Thereafter, the EU adopted the ideas of this movement, in 2017 and 2018 resolutions on product durability and repairability were passed in the European Parliament. Repairability of electronics is currently on top of the political agenda in the EU and new regulations on R2R are expected during 2022. The Commission has announced several other initiatives that will also push these policies. This initiative has gained global interest in recent years (Jin, Yang & Zhu, 2021); countries outside the EU and the US are also pursuing R2R policies, e g Australia.

In the EU, the Right-to-Repair refers to both rights during the legal warranty period and after its expiration, but also to the right for consumers to repair products by themselves (European Parliament, 2022). Hence, the EU has passed regulations regarding the access to spare parts, warranty, and labeling to indicate repairability (a repairability index) (Jin, Yang & Zhu, 2021).

In summary, the new Right to Repair movement has the potential to reduce the number of electronics considerably by extending product lifespans and allowing reuse. Under the right to repair, according to Hernandez et al. (2022), consumers can decide what to do with their products when they fail before replacing them.

As described by the European Parliament (2022), the main reason why consumers don't repair is because of high cost. This is the reason why, the independent repair has to be supported in order to provide more confidence to consumers since independent repair is more accessible to the public. The barriers identified, as previously mentioned, influence the cost of repair, for instance, if a device is intentionally designed to be difficult to open, it will take more work hours to be repaired. R2R policies therefore aims to reduce the cost of repairs (Jin, Yang & Zhu, 2021). Making the product easier to repair contributes to the Circular Economy (Svensson et al., 2018). The Ecodesign Directive 125/2009/EU is currently being reviewed by the European Commission, as it can be used as a tool to promote repair and limit its barriers.

Under the Right-to-Repair proposals, the customers would in many cases be able to carry out the repairs by themselves, which is a very positive achievement. However, in this regard, it is assumed that an independent repairer might be able to carry out a repair service easier and faster than an average consumer because the repairers have acquired the necessary technical knowledge through hours of practice and development of their profession. Therefore, facilitating repair by professionals is similarly important as a further step towards better reparability by consumers (European Commission, 2021).

On the OEM side, there is a lack of confidence in the independent repairers because they might not have the expertise required to repair recent models (Svensson et al., 2018, Dalhammar et al., 2021).

New models are introduced all the time, and, in addition, more complex designs are being produced due to technological advancement. Thus, it is important to include the independent repairers and recognize their role in the repair sector. Moving towards a more circular economy could generate a net increase of 700,000 jobs in the EU by 2030 (European Commission, 2020). Some of these new jobs will be created due to the expected rise of some services such as repairing and maintenance of electronics.

Moreover, in the EU there have been interesting national efforts, such is the case of Spain, which has passed legal initiatives intended to adopt the Right-to-Repair proposal to promote repair and reuse, to achieve the objectives of the *Spanish Strategy for the Circular Economy and Circular Economy Action Plans which is the implementation of the European Circular Economy proposal in the country*. New proposals have been implemented to extend the lifespan of electronics, such as the Repairability Index which is intended to replicate the one implemented in France and the increase of the percentage of the devices prepared for reuse. Further details are commented in the literature review.

For this reason, the General Law for the Defense of Consumers has been amended to guarantee the availability of spare parts of products up to 10 years after they are placed on the market. In said law, the warranty period has also been extended, and was increased from 2 to 3 years. More recently in April 2022, the new Spanish Law on Wastes and Contaminated Soils was published, establishing additional obligations for producers regarding more repairable products and promoting the availability of spare parts and tools, instruction manuals, and technical information that improves the accessibility of repair. Additionally, the creation and implementation of a repairability index has been mandated, which is currently in process of evaluation, and which would be similar to the one enacted in France in 2021. Lastly, Spain was a pioneer in implementing preparation for the reuse objectives of WEEE, beginning in 2015. For this reason, in the new law, the objectives have been increased, starting in 2025 with 5% and growing progressively to 15% in 2035.

The above-mentioned law amendments and initiatives are intended to protect consumer rights directly, but also, indirectly, to foster the extension of the lifespan through repair and reuse. We cannot think or talk about repair without considering repairers. For this reason, it is necessary to understand the fundamental and critical role that the independent repairers have in the Circular Economy in the electronics sector. To understand how consumers can exercise their right to repair and all the necessary changes, it is important to understand how the new regulations will positively influence the repair sector.

There is a lack of research on the repairers' perspectives, especially after the implementation of these new reforms and legislative changes that seek to benefit the repair sector and foster device maintenance. There are many studies that research the consumers' side regarding attitudes towards the end-of-life of small information and communication technology (ICT) devices in Spain (Bovea et al., 2018), the behavioral insights into personal electronics repair (Lopez, 2021), increasing repair at a household level (Laitala et. al, 2021), repair practices in Barcelona (Matarin et al., 2022), consumption behavior (Dalhammar & Maitre-Ekern, 2019), life extension scenarios (Sández et al., 2021), attachment factors in small household (Mulet et al., 2020), consumer practices (Sonego et al., 2022), and reuse on electronic equipment (Bovea, 2015). Conversely, a few studies examine the repairers themselves (IIIEE & EEB, 2021). Of course, the role that consumers can play in Circular Economies is intriguing in itself (Dalhammar & Maitre-Ekern, 2019) since they can contribute greatly to the achievement of the objectives of sustainable consumption, and thus, evaluating their practices is necessary. However, the

literature on the topic largely focuses on consumer attitudes, often overlooking the repairers themselves.

The independent repairers impact on the Circular Economy, specifically under the new law initiatives and Right to Repair movement, has not been reviewed sufficiently since the most important changes have been passed recently through laws and others are yet to be passed. Thus, if the Right to Repair movement and the European Commission seek to make access to repair easier, faster, and cheaper, the independent sector must be reviewed.

1.2 Research Objective and Questions

With the purpose of examining, understanding, and addressing the problem identified, this thesis is intended to gain knowledge about the repair sector, emphasizing the independent component to foster the repair of electronics, and specifically, of mobile phones, to allow for the development and adequate implementation of the Circular Economy proposals.

By analyzing the qualitative data obtained from semi-structured interviews, certain conclusions were reached that offer recommendations that can help the future development of this movement.

Thus, the central question of this research is the following:

1. How do the recent regulations and policies that are currently implemented, and those that are expected influence the independent repairers sector?

By means of the literature review, this becomes:

1.1 What policies can be implemented in the independent repairers sector in Spain in order to benefit this sector?
1.2 What is the attitude of the repairers toward the new proposals?
1.3 What is the current situation of the independent repairers sector in Spain?

1.3 Scope and Limitations

1.3.1 Scope

Firstly, while it is true that electronic waste is a global problem, this thesis is focused on the geographical scope of the European Union, specifically Spain. The reason for the selection of this scope is because of the large amounts of waste that this region produces every year. The global projection of e-waste generated per capita in 2022 is 7.8 kg, as estimated by Forti et al. (2021) in their global e-waste monitor. However, the yearly production per capita of this waste stream in Europe is 16.2 kg, which is slightly more than double of the global average.

Secondly, another factor in the limited geographical scope of this thesis is the political support that this movement is currently having in the European Union since electronic waste is on top of the political agenda with the Circular Economy proposals and objectives. Moreover, in 2021 and 2022, crucial changes have been announced, and new regulations and policies are expected in the short term as well as those complementary to achieve the long-term objectives of the CE agenda.

Thirdly, the Right to Repair movement has been pushed in the European Union in the last few years, achieving good results. There are some references to the Right to Repair movement in the US since the movement originated there. Also, a reference is made to the Waste Reduction Model (WARM) developed by the US Environmental Protection Agency regarding the air emission produced by the electronic equipment reviewed in this thesis.

Fourthly, the 54 EEE product categories (Forti et al., 2021) are grouped into 6 general categories in the WEEE Directive Annex III and IV that correspond closely to their waste management characteristics. However, this thesis is focused on small IT equipment, and specifically, on mobile phones. As can be easily observed, in European daily life, the mobile phone is one of the EEE that is most commonly used. From a young age, people begin to have their own phones. For instance, as of 2019, by the age of 8, 19% already own a phone, and the average increase in older groups (BBC, 2019; Common Sense, 2019).

In addition, as is commented in the literature review of this thesis, Spain, together with Singapore, is one of the countries with most mobile phones per capita (Dorado, 2018; Puentes, 2018). As it is commented in further sections, specifically in the literature review, mobile phones are the device that is most commonly repaired and that is why only the repairers who work on these devices were interviewed.

Moreover, the fifth reason is that Spain is one of the countries that produces the most waste from this stream in Southern Europe as it can be observed in *the Global E Waste Monitor* by Forti et al. (2020). In previous years, during the initial phase of the waste management system, Spain lacked efficiency due to low rates of collection, however, the system has evolved since its beginnings, and in past years, collection rates have increased consistently and remarkably, reaching greater results than other countries in the EU as it is noted in the latest annual reports of the collective systems of extended producer responsibility in Spain (Recyclia, 2021, European Recycling Platform, 2020). In addition to this progress, currently there is a strong interest in prevention strategies, as it has been announced in the Spanish New Circular Strategy (2020), Action Plan for the Circular Economy 2021-2023 (2021), which includes repair. Furthermore, legislation has been modified to establish new legal obligations regarding EEE. More recently, in 2022 provisions related to the repairability of devices and easing their repair where included in the Hispanic legal framework. To conclude this point, Spain has announced that it will implement a Repairability Index (RI) similar to that of the French. A public consultation has been carried out by the local government and currently is under revision to implement the index.

The final reason for this scope is because of language, since the researcher is a native Spanish speaker and this could help to reduce language barriers when obtaining information such as official government communications, laws and regulations, and relevant academic literature, as well as when carrying out interviews with the population identified.

1.3.2 Limitations

This study mentions, in the literature review, electronics as a general group of products in some sections because many regulations, movements, reports, and studies have been taking this approach, and thus small ICT and specifically mobile phones are regulated under this more general group. Mobile phones were selected due to the fact that several research studies have found that these devices are the category most commonly reviewed.

Moreover, regarding the population interviewed, only a small amount of independent repairers in Spain were interviewed due to restrictions in terms of human capacities and time limitations. Thus, the findings represent the point of view of a fraction of the individuals in this population.

At the time when this research was carried out, there were some policies that had not yet entered into force, such as the Spanish Repairability Index, or all the new amendments and requirements to allow and ease repairability in the Ecodesign Directive.

This last point is not precisely a limitation, but an aspect that must be considered. Due to the geographical location of the researcher (Scandinavia) and the institute where this study was

developed (the IIIEE at Lund University) there are several references to Scandinavian researchers who produced important knowledge to the European Commission and Parliament, as well as for local authorities in Sweden. Naturally, many Spanish researchers, studies, laws, and regulations were consulted as well. The advantage of researching this topic on the European Union level is that, for instance, the directives reviewed in this thesis were mandated at the communitarian level and adopted at the local levels. Basically, what is decided by the European Commission, has to be implemented in the member states that form part of the community

1.4 Audience

This research is intended to reach policymakers, practitioners, and researchers of the Circular Economy, but primarily those who are involved and interested in the electronics sector and the Right to Repair movement, in order to provide them with knowledge and understanding about the independent repairers and their key role in the Circular Economy. The findings of this thesis can be also helpful to mobile phone producers, since, as mentioned previously, there has been something of a "monopoly" for the repair sector (Hernandez, 2020) where access to repair was mostly *closed* and now is expected to transition to more *open* access to repairs (Svensson et al., 2018), and these changes will affect – and involve - producers. Additionally, the OEMs are the actors being obliged to provide the spare parts during a specific period of time, as it has been recently mandated in laws. The findings can also be useful for those third companies and individuals who perform repair services, as well as to other producers and repairers of electronics of different categories.

2 Methodology

This chapter outlines the process and approaches taken by the researcher to identify the problem, obtain findings, and reach conclusions that can together provide context and insights for the audience mentioned above.

2.1 Research Approach and Design

Because the research question of this thesis is fundamentally qualitative, so too is the research process developed to answer it. Since the opinion and understanding of the independent repairers will be studied, a qualitative approach is necessary to understand the meaning these population give (Creswell & Creswell, 2018) to the movement pushing repair and all the new policies and regulations that are influencing the repair sector towards a CE that support activities that help to meet the environmental objectives. How this new situation, and the new changes that stem from it, influence the sector can be best studied through a qualitative analysis.

Moreover, the research that will be carried out needs a qualitative approach since, as was mentioned in the problem definition section, little research has been carried out on the independent repair sector regarding the objectives of the CE and the Right to Repair Movement. This shortage occurs for two reasons, firstly, because most of the research has focused on consumers and producers, and secondly, because this topic has only recently started to gain momentum, especially in the last 2 years. Hence, not all the variables are known at the moment, and still others are evolving (Creswell & Creswell, 2018).

Additionally, the implementation of the new regulations can potentially influence the policies on the repair sector previously mentioned in chapter 1. A case study design is adequate for this thesis due to the fact that the nature of the problem researched requires the analysis of more than one individual (Creswell & Creswell, 2018). Moreover, since this research is focusing on a contemporary event, it is also sufficient to develop a case study to understand the how's and why's (Yin, 2014). In addition, since some of the policy measures in Spain to foster repair are still in the implementation process (for instance, the repairability index or the revision on planned obsolescence), or have only recently entered into force, therefore it's important to observe how is the current situation in the repair sector.

In this research the objective is to observe and identify possible positive and negative implications (Yin, 2014) that the new regulations and policies fostering repair can have in the independent repairers sector. At this point, it is very important to clarify that this thesis is focused on the Spanish case in spite of the references to other countries such as France, Sweden and Austria, which are not studied as multiple cases, but which have implemented some the policies, such as the Repairability Index (France), tax deductions (Sweden), or repair networks and vouchers (Austria), that can serve as examples of good practices that have already been satisfactorily implemented in the field of repair and which could be replicated in Spain. Because of this transferability to the Spanish context, these policies are briefly explored in the interviews.

A case study was considered to be used because the specific case of Spain is being studied and the literature review helped to identify all those new aspects that influence the repair sector. The theory is created by means of the findings of the literature review and analysis of the qualitative data collected. This mixed method was the most suitable to research this type of problem, in which the situation is already evolving and moving towards more repair.

2.2 Philosophical Approach

Briefly, this thesis follows a Constructivist approach since, to understand the points of view and opinions of the researched population it is important to rely on their point of view (Creswell & Creswell, 2018). In addition, the researcher acknowledges that he does not have the technical

knowledge, expertise, or experience working in the repair sector that independent repairers have acquired.

2.3 Data Collection

Due to the problem identified, the population studied, the relatively recent initiatives and the different stakeholders involved, different sources were consulted to explore different perspectives. Literature from multiple different sources was reviewed to identify the scope of the research (Creswell & Creswell, 2018).

2.3.1 Literatura Review

The first stage of obtaining the information and data necessitated a literature review in order to identify the problem and ascertain its importance. In addition, the internet allowed for the review of the opinions, perspectives, and findings of other researchers. Literature was used to frame the problem (Creswell & Creswell, 2018), by means of reviewing academic and gray literature written in English and Spanish, which is particularly important given the evolving context of this topic at both the EU and national levels.

At the very beginning of the development of this research, the principal focus was the electronic waste management system and recyclability in Spain. However, after the literature review, it was found and concluded that at the moment, in the EU and in Spain, the main approach toward electronics is prevention as it has been established as a priority in the waste hierarchy. Google and Google Scholar and Lubsearch were used to find and review gray and academic literature accordingly. Thus, the search began from the general to the specific. Keyword searches began with "electronic waste", which, after the review of literature on the topic, snowballed to include other terms, such as "waste management", "waste reduction", "Circular Economy", "repair", "repairability", "spare parts", "repairers", among many others. Keywords were searched in both English and Spanish.

Those keywords allowed for a review of academic literature such as journals, reports, articles, studies, and assessments, among others, that served as a basis to frame the research, identify the problem and its significance, develop the research questions, and provide a deeper understanding to the researcher on primarily about the following topics:

- Previous waste management strategies, such as collection and recycling
- The Circular Economy approach to waste prevention
- The Ecodesign Directive and its previous requirements for energy efficiency as well as current approaches on repairability
- Extended Producer Responsibility (EPR) and its relationship to collection and ecodesign
- Durability of electronics
- Consumer behavior towards electronics and repair
- Analysis of the current situation regarding the regulation and legal aspects related to repair in the electronics sector
- Examples of effective policies that have already been implemented

In the literature review and in the framing of this research, the gray literature had an important role since repair and repairability is being pushed in governments, for instance in the EU, where Circular Economy plans rely on legal instruments to achieve the objectives. This topic has been evolving in the EU parliament and National Congresses (Spain). Thus, throughout the analysis of this type of literature, the following information was reviewed:

- Latest official communications on the topic on the EU and Spain levels
- Law amendments to previous legislation and new initiatives
- Tracking legislative procedures
- Circular Economy Action Plans on the EU and Spanish context
- Legal context of electronics such as new obligations to producers on design, legal warranty, the information provided, and durability

To conclude, the literature review was helpful to identify the important stakeholders that needed to be interviewed to complement the information gathered and helped to triangulate the information.

2.3.2 Field Research and Qualitative Data Collection

In order to understand and analyze how the situation is evolving in Spain, it is important to practice qualitative research methods. "Researchers collect data themselves through examining documents, observing behavior, or interviewing participants" (Creswell & Creswell, 2018). For that reason, the researcher traveled to Spain to conduct in-person interviews with the independent repairers

Traveling to the place of study allowed analyzing the data collected to create new knowledge that can help to create new policies specialized to that sector.

Repairers were interviewed on a voluntary basis, using open-ended as well as specific questions which were prepared in advance to complement the information obtained by the literature review since the participants can offer additional insights into the research questions. In the cities of Barcelona and Madrid, the researcher developed face-to-face interviews with independent repairers. With the Google Maps application, the location of their business was found, which was beneficial because this method did not require previous preparation or contact. In addition, repair shops where visited while walking in the streets of Madrid and Barcelona in centrical zones in which most of the shops are located. Most of the repairers semi-structured interviews were carried out since a guide previously prepared with a set of questions was followed to delve into the specific topics. However, the interview structure allowed for other responses and topics since this led to interesting findings.

For these purposes, 30 repair shops were visited in Madrid and Barcelona. The repair shops visited were those small businesses that are easily found in the city centers. In those repair shops, some people refused to be interviewed mostly because they were busy with customers, or because they didn't know how to repair, due to the fact that the person in the repair shop was in charge only of sales and not repairs, in other cases the repairer wasn't at the shop, or in some cases because they didn't speak Spanish. However, those who affirmed that they know how to repair proved to be experts. Others refused to be recorded and in those cases the interview did not took place. Thus, 13 interviews were carried out face-to-face with repairers. Most of the repairers were men between 25 and 45 years old. It has to be mentioned openly that the repairers did not provide too much data due to the fact that not all the people interviewed had the technical knowledge and expertise despite of owning a repair shop or working there.

In the design of the interviews, 2 protocols and guides are considered to triangulate information between the same group of participants (Croplay, 2015). Each set of protocol contain 15 questions, which in total conform a set of 30 questions. In this section of the methodology is worth to mention that the logic behind each question is mentioned and explained in a detailed manner in the chapter named Findings, due to the fact that the protocol was elaborated with the findings of the literature review. The topics on the academic and gray literature reviewed allowed the research to formulate the questions of each semi-structured interview to all the stakeholders to make a more holistic analysis. To begin with, the different questions included in

the questionnaire, where planned to delve deeper into different topics that were found in the literature review and that the researcher consider that where important to get more information. Moreover, a big percentage of the literature reviewed was done considering the consumers or producer perspective. Thus, based on the findings of the different perspectives and findings of studies of other stakeholders, it was possible to formulate questions that helped to delve deeper on the independent repairers perspective.

2.4 Analysis

Since the information is contained in the qualitative interviews, the data was winnowed to focus on the most important aspects and information that emerged (Creswell & Creswell, 2018).

Recorded interviews were carried out in mostly Spanish, with some English due to the fact that even though Spain is a Spanish/Catalan speaking country, many of the repairers speak the language very basically. The transcriptions of the interviews were translated to English. The researcher used qualitative computer software QSR NVivo to analyze the qualitative data. Computer assisted analysis helped to do this analysis faster, with a more detailed review (Croplay, 2021).

Expected codes were obtained from the literature review, while surprising codes emerged from the qualitative interviews (Creswell & Creswell, 2018). The description of the settings or individuals is considered for the case study approach (Creswell & Creswell, 2018).

The most important aspects about the current situation, those factors that are influencing the repair sector, and those that will be implemented and will influence this sector in the near future were identified as the first step of the research process. The primary data was collected by means of the literature review and desk research.

A hybrid approach was used for the coding of qualitative data since some of the codes derived from a literature review and previous studies which helped to identify relevant data (deductive method), which functioned as a set of a prioritize codes and then new codes were added (inductive method), the field research was centered on the findings of the literature review findings.

2.5 Theory

The theory is concluded after the literature review and all the different topics mentioned, all of which influence the repair sector. The theoretical formulation of the thesis is that in the upcoming years the role of the repairers will become critical in extending the lifespan of the devices. If repair rates are expected to increase, the repair sector needs to be well equipped for this transition. The early preparation of this sector will contribute to its growth over time.

Additionally, since customers are being encouraged to more repair and exercise their so called "right to repair" will contribute to more repairs in both sectors the official and the independent, which lead to an empiric theory.

2.6 Ethical Considerations

Ethical considerations are an important part to consider in the thesis research, and so the framework provided by Creswell & Creswell (2018) is followed. The thesis research is independent and was developed and carried out with the supervision of both the researcher and professors working in the IIIEE.

The analysis and conclusions will be personal and there is any external influence from any other agent. The participants involved were interviewed only with their voluntary consent and will be informed about the purpose of the interviews. The information provided and the knowledge produced will be communicated to them in case they wish to access it.

The participants involved in the qualitative research will not be affected by participating in the research. Hence, the analysis and conclusions were made on an anonymous basis in which individuals are identified by specific characters, such as letters or numbers to keep confidentiality on their identities. It is important to mention that, regarding this point, special attention and consideration will be put in order to avoid any negative consequences to the participants or to the researcher.

The information will be managed according to the consent of the participants in order to avoid conflicts related to their privacy and dignity. Is important to mention that, in information obtained from government agencies and other public sector actors, there is much information that is intended to be publicly available online. Sensitive information will be kept strictly for research purposes and commented on with the researcher's supervisor to avoid conflicts.

Moreover, the information and data obtained from different sources and produced by other researchers or institutions are referenced under APA guidelines.

3 Literature Review

This section contains different topics that were researched to obtain information and an understanding of the importance of repair. The research ranges from the general to the specific, thus, the topics involved study several topics which involve the repair sector.

The first section analyzes the teleological and final causes of the repair. The second section studies the repair sector and focuses on the scope of this master thesis, which is the mobile phone. The third section reviews different policy instruments that lead to repair of electronics in general and in specific mobile phones. In the final section, the most important stakeholders are discussed. Each section contains a brief conclusion of each of the topics reviewed.

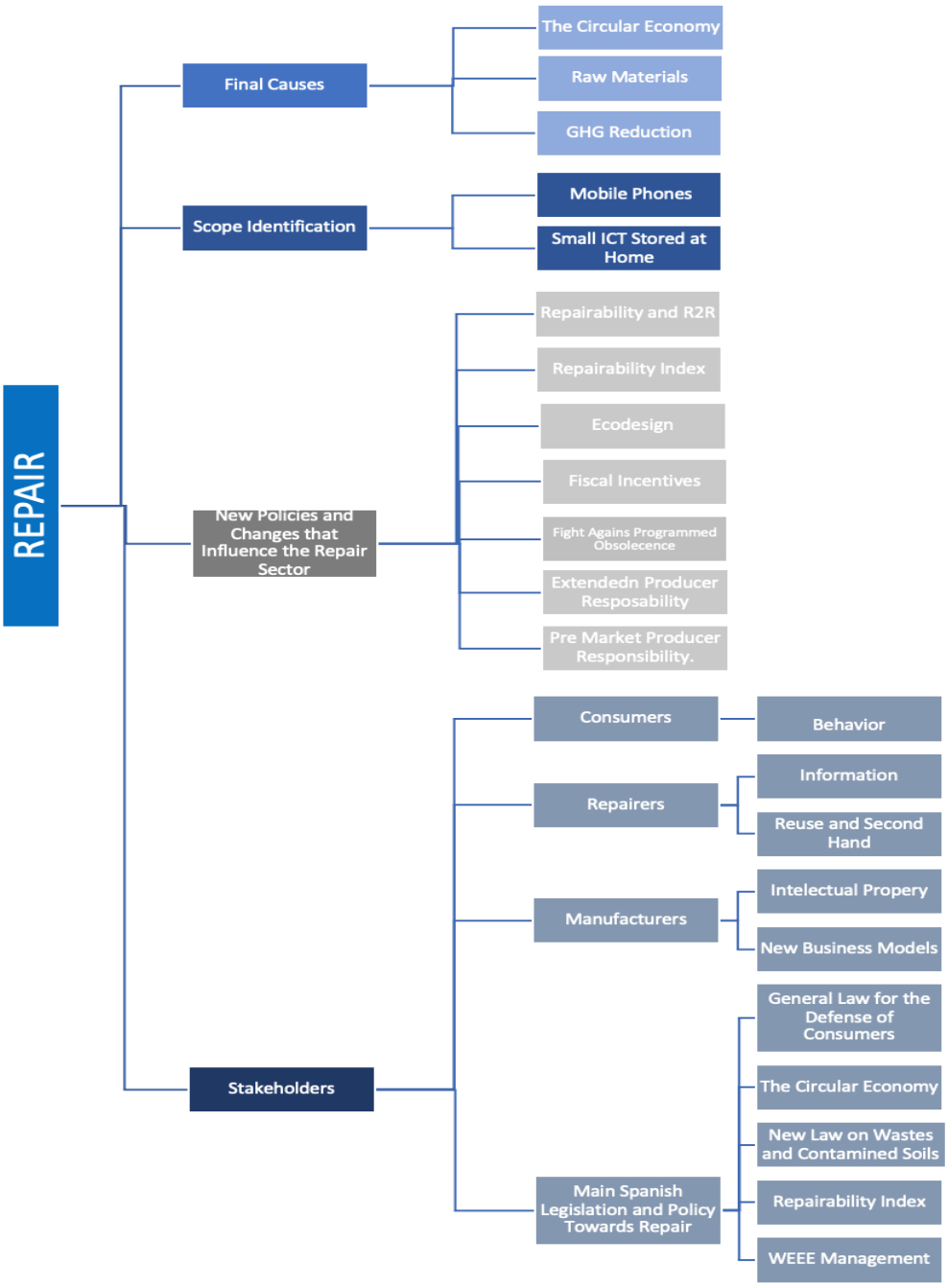


Figure 3-1 'Diagram of the Topics Covered in the Literature Review'

Source: Own elaboration

3.1 Final Causes

What was analyzed in this section is the objective or results that the repair has, or in other words, what is achieved by implementing policies that foster repair. This section can be named Environmental Benefits of Repair, however, the name given is also appropriate, given the topics reviewed. Of course, this is not a limitative list since many other results are obtained, for instance, stopping the illegal dumping of electronic waste in less developed countries. With the above being mentioned, the scope is focused in Spain and the European Union.

3.1.1 The Circular Economy

Circular Economy proposals have only recently started to be pushed in the European Parliament and Commission. In 2015, the Action Plan for the Circular Economy was published in which 54 measures were included to influence and change products from its initial stages. Since then, this new proposal for the economy has been pushed and has achieved continuous progress. As the concept of Circular Economy (CE) continues to grow, traditional product policies are becoming supplemented by new policies which aim to, for example, lengthen product lifespans and encourage more repairs (Dalhammar et al., 2021).

The proposed changes are quite complex as multiple factors must be considered in order to achieve the expected results and thus the objectives cannot be reached overnight. Implementing the changes proposed on the CE without considering different factors can lead to a mistaken result or not very effective policy intervention. Researchers from the IIIEE (2021) suggested that in order to evaluate the Circular Economy, a PESTEL analysis must be undertaken because many different factors can influence its development. Hence, the political, economic, social, technological, environmental, and legal context and feasibility of policies need to be considered. Actors in both public and private sectors are increasingly concerned about the environmental impacts of human activities as resource use continues to grow (IIIEE, 2021) and for that reason a PESTEL analysis is important to evaluate the possibilities to have an effective intervention. It will be impossible to achieve a Circular Economy without appropriate policy interventions (Dalhammar et al., 2021).

As announced in the Circular Economy Action Plan, the Commission is proposing new rules to make virtually all physical goods on the EU market more environmentally friendly, more circular, and more energy efficient throughout their entire lifecycle, from the design phase through to the use and end-of-life phases (European Commission, 2022). To achieve this ambitious objective, it's important to analyze the different factors considered in the PESTEL analysis. According to the European Court of Auditors (2021) the Commission has identified electronics and information and communication technology (ICT) equipment as one of the key value chains requiring "urgent comprehensive and coordinated actions".

The Circular Economy can achieve social benefits in the mid-term. For instance, moving towards a more circular economy can generate a net increase of 700,000 jobs in the EU by 2030 (European Commission, 2020). Many of those new jobs will be created due to the rise of services such as repairing and maintenance of electronics. It has the potential to reduce the costs to consumers by 7% by 2030 and 14% by 2040 (PACE, 2019). The economic benefits for the electronics sector can be enormous.

In addition to these social benefits, the Circular Economy's environmental benefits are perhaps the most important and fundamental. CE can help producers make much more, with much fewer resources, reducing the burden on the earth caused by material and energy consumption as well as helping to protect ecological goods and services from pollution and waste (IIIEE, 2021). The Action Plan for the Circular Economy contemplated in the European Green Deal has the objective of decoupling growth from the use of resources through the design of

sustainable products and harnessing the potential offered by secondary raw materials (European Commission, 2022). In the currently dominant linear economy, humans are using too many resources, too fast, and not reusing enough of them (IIIEE, 2021).

3.1.2 Raw Materials

According to the European Commission's Inception Impact Assessment on Ecodesign and Energy Labeling (2020), the functionality of mobile phones (particularly smartphones) has been increasing with time, which correlates with an increase in demand, storage capacity, and material usage in manufacturing. Even in small quantities, many of these raw materials are of international concern because of their impacts beyond the environment: socially, economically and geopolitically (European Commission, 2020). In many cases, global markets are dependent upon suppliers in just one or two countries for the majority of the supply of these critical materials (IIIEE, 2021). Additionally, as a result of the digitalization era, electric mobility, and the energy transition, these conflict minerals are vital for development. Countries that have strategic and critical materials have begun to realize the potential effects that these mining industries can have on their economies, such that Lithium has been referred to as "white gold". Due to the high importance of several raw materials that are used in the electronics, and in specific in mobile phones special attention has to be putted on the durability of the devices and its design. The following example can provide a reference to have a quantitative idea of the importance of these materials. There is 100 times more gold in a tone of mobile phones than in an ore of gold (PACE, 2019).

The EU depends to a large extent on the importation of strategic materials such as lithium, among others as it has been reported by the European Commission in 2020 in the study on *Resiliency of Critical Raw Materials*. Most portable consumer electronics today contain rechargeable lithium-ion batteries (LIBs), a trend that will only continue to increase as LIBs become the preferred technology for smart consumer electronics and light electric vehicles (LEVs) (IIIEE & EEB, 2021). Therefore, the strategic materials require strategic management due to their global importance, their role in the digital world, and most importantly, because they are limited resources that cannot be wasted.

As noted in the *Ecodesign preparatory study on mobile phones (2021),* ecodesign requirements, even without energy labeling, can bring about 35% less material consumption, and 19-23% less critical raw materials in products placed on the market in 2030, as compared to a no-action scenario. Thus, through reducing material and energy consumption (in both the production and use phases), smarter designs can increase the eco-efficiency of many products (IIIEE,2021)

Moreover, fiscal measures imposed on producers by the national governments can encourage ecodesign and repairability. From the perspective of the CE, high taxes on materials and low taxes on labor would encourage product durability and repair (as repair is more labor intensive than disposal) and are therefore critical to achieving CE's objectives (Maitre-Ekern & Dalhammar, 2019). By raising costs on both the purchase side (through virgin materials) and the disposal side, consumers would be incentivized to conduct more repair and reuse and toward the resulting lowered costs through tax relief (Milios, 2021). Tax incentives can be considered an option to incentivize and foster the uptake of the use of secondary raw materials.

The EU is at the forefront of the circular economy and has already increased its use of secondary raw materials. For example, more than 50% of some metals, such as iron, zinc or platinum, is recycled which could cover more than 25% of EU consumption. However, in other cases, such as the rare earth metals gallium and indium and other materials used in renewable energy technologies, the contribution of secondary production is merely marginal (European Commission, 2020).

With the high rate of technological innovation and such a wide variety of electronic products disposed of annually, it is difficult to determine the specific composition of a "typical" electronic product (US EPA, 2019). In the new legal inputs proposed in the *Ecodesign Preparatory Study on mobile phones, smartphones and tablets (2021)*, it is expected that soon producers, importers, and other such authorized representatives will need to include in the technical information and in the public documentation (e.g. on freely accessible websites) the indicative weight range of certain critical materials as well as environmentally relevant materials, for example, cobalt used in batteries; tantalum used in capacitors; neodymium in loudspeakers, vibration motors and other magnets; and gold in any component.

Structuring information on the environmental sustainability of products and transmitting it by means of a digital product passport will help businesses along the value chain to access valuable information pertaining to their work which can improve environmental performance and efficiency, prolong product lifetimes, and reduce the need for virgin materials, all of which would help to save money and limit dependencies to raw materials and strategic raw materials (European Commission, 2022).

Obtaining these strategic metals can have large environmental impacts, especially as most of the mining activities emit high levels of greenhouse gasses (GHGs) due to the energy- intensive processes to obtain the raw materials. For example, the most significant environmental impacts from LIBs are caused by energy-intensive material and cell production processes. (Dunhen et al., 2020; Parajuly, 2020 as cited by IIIEE, 2021).

Energy transitions, digitalization, and electromobility can be hindered if these strategic materials are not used appropriately. Santos (2018) found that the solar photovoltaic panels will require large quantities of strategic materials and thus recycling can help to guarantee its supply in the future when the panels that are being used currently become waste.

According to Circular Economy proposals, the value of these materials can be kept in the economy and be recycled to be used as secondary materials instead of being wasted. Additionally, repair and reuse activities can lead to a reduction in the use of these materials as well as GHG reductions.

3.1.3 Greenhouse Gas Reductions

The new ecodesign proposals have a strong potential to reduce GHG emissions in the European Union. For instance, according to research carried out by the IIIEE & EEB (2021), if all the phones and personal tablets sold in the EU by 2030 contained removable and repairable batteries, then 674,834, tons of CO2 would be mitigated, approximately 30% lower than business as usual scenario. Globally, 50% of all greenhouse gas emissions and 90% of biodiversity loss is driven by the extraction and processing of primary raw materials (European Commission, 2022).

According to the Waste Reduction Model on Electronics (WARM model) developed by the United States Environmental Protection Agency (2019), source reduction activities such as repair and second use can reduce GHG emissions from the production stage by reducing the number of electronics manufactured. Because e-waste may also contain particular valuable metals such as copper, nickel, indium or palladium, recycling these products avoids GHG emissions from production of new materials and thus contributes to climate change mitigation efforts (European Court of Auditors, 2021). However, one must note that electronics are not always recycled into new electronics, but rather are sent into an open loop system (US EPA, 2019).

Moreover, modularity and repairability can increase a product's lifetime from 3 years to 5, decreasing global warming impact annually by 28% and counteracting the higher initial impact since several research has found that the highest environmental impact of mobile phones is caused during its production.

It has been proposed in the Circular Economy agenda to foster the use of secondary materials in electronics. By substituting virgin material with recycled materials, which are usually require less CO2-intensive processes, producers can reduce the CO2 emissions of electronics (e.g., -95% of CO2/ton for recycled aluminum and -83% of CO2/ton for recycled plastic) (PACE; 2021: Material Economics, 2018). In the same track, in the aforementioned WARM model (2019), the component mass share of electronics is described, which, for portable electronic devices is the following: Ferrous metal 7%, aluminum 12%, copper 2%, other metals 4%, plastic 7%, printed circuit board 14%, flat panel display module 16% and battery 18%.

Increasing product durability and repairability is one way to save resources: if a product has a longer lifetime, fewer new products need to be produced. However, this resource saving may be compromised by increased environmental impacts in other phases of the lifecycle (Dalhammar, Milios, & Richter, 2019).

3.2 Scope Identification

Among all the electronics, the literature analysis helped to identify the material scope of the thesis, which is on mobile phones. Therefore, the following section describes the topics that were reviewed to reach the decision about selecting these devices in particular.

3.2.1 Mobile Phones

Mobile phones have become one of the most important devices used nowadays and have replaced other devices such as music players, cameras, audio recorders, calculators, among others. Sales grew rapidly beginning in 2009, reaching annual numbers of approximately 1.5 billion phones between 2016 and 2020 (Valero, Calvo & Valero, 2021). Cumulatively, between 2007 and 2020, almost fourteen thousand million telephones were placed on the market, as well as over one hundred and sixty million electric tablets sold in 2020 alone (Torrubia, Valero & Valero, 2021).

It is crucial to regulate the aspects related to the durability of phones as nowadays almost everyone in Europe uses one. No scientific or academic publication was needed for this simple observation on the prevalence of mobile phones in daily life. As an example, Bovea et al. (2017) interviewed Spanish households and found that 85% owned two or more mobile phones, 20% owned at least five and just 1.5% owned none. Similarly, Puentes (2018) references a study done by Back Market in 2016 which found Spain, along with Singapore, to be the country with the most smartphones in the world, with 92% of residents owning at least one of these devices. Along the same lines, Dorado (2018) noted that in Spain there are 52 million mobile phone lines, meaning the country has more phone lines than inhabitants. which was reported to be 46.79 million in the latest Worldometer elaboration by the United Nations.

As identified by the *Inception Impact Assessment on Ecodesign and Energy Labelling* (2020), published by the European Commission, consumers replace their smartphones every 2 or 3 years on average. Additionally, in many cases phones can be replaced faster due to external factors such as robbery since this device is commonly stolen due to its material value.

Lifespan extension by means of repairability has the potential to influence the behavior of the users and therefore avoid rapid replacement. While it is true that all electronic devices are replaceable, there are those, like mobile phones, that are more easily replaced due to their short

lifespan. Conversely, the lifespan on other electronics is considerably longer, with dishwashers having an average lifespan of 10 years and refrigerators lasting, on average, 14 years (Fernandez, 2015). Ertz et al. (2019), in their study, *Experiences from Consumers and the Repair Industry*, found that survey respondents reported that their electronic appliances had broken down in the past 2 years. Of the electric appliances included in the survey, mobile phones were the most frequently broken (28%), with dishwashers and laundry machines accounting for 12% of failures, and less than 10% reporting a broken refrigerator, freezer or stove (Ertz et al., 2019).

In surveys conducted by the IIIEE (2021), the most common reason for mobile phone repair was related to battery issues, which is easily remedied if battery replacements are accessible. The market share of smartphones with non-removable batteries reached 90% in 2017 (IIIEE & EEB, 2021). Therefore, since battery issues are the most common problem for mobile phone users, the European Commission (2022) is pushing a mandatory requirement for producers to design their devices with a user-replaceable battery. This mandate means either returning to smartphone design as of the 2000s, with a slide out battery or modular components, or a completely new solution (European Commission, 2022). By regulating battery removability and replaceability, the EU can reduce the unnecessary replacement of devices by 39 million units in 2030 alone (IIIEE, 2021).

In the case of mobile phones, most of the impact is caused during the production phase, due to all the raw materials used, the energy consumed in their obtention, and also in the manufacturing of the device, as mentioned above in the section corresponding to raw materials and GHG gasses. Mandatory Ecodesign standards may be suitable for some but not all product groups (Dalhammar, Milios, & Richter, 2021).

3.2.2 Small ICT Stored at Home

In Spain, many people tend to store their small ICT equipment at home (Bovea et al., 2017). The European Recycling Platform Spain (2020) reports that small computer and telecommunications equipment (with external dimensions less than 50 cm) have the lowest rate of recycling. Home storage is a big issue because users either fear losing the information stored within them or because of the so-called "treasure effect" where people become personally attached to their devices (ERP, 2020).

The Commission is exploring options to incentivize the return of small electronics such as old mobile phones, tablets and chargers stored at home. The objective is to promote circular business models for these products by extending lifetimes and improving collection (European Commission, 2022). Future research can examine how and when collecting programs for these devices can be implemented efficiently.

Collaboration between different actors will be required to make this process a win-win situation, because consumers are not expected to initiate it themselves since no past example exists to provide guidance. The win-win situation in this context means that both the consumers and the collectors can benefit.

Some companies have implemented take-back programs, such as the one put in practice by Apple when consumers purchase a new device. With this type of action carried out by producers, the availability of spare parts can be obtained by means of harvesting old devices and selling the refurbished products at lower price.

3.3 New Policies and Changes That Influence the Repair Sector

This section of the literature review analyzes different policies and changes that have been adopted. In recent years, the push to repair movement has gained strength in the European Union.

3.3.1 Repairability and the Right to Repair (R2R) Movement

Within the European Union, repair activities and the related aspects reviewed in this thesis are regulated in different directives, some of which refer exclusively to the production of electric and electronic equipment while others focus on consumer behavior. Hence, the most important legislation is the following: the Ecodesign Directive (2009/125/EC), the Sales of Goods Directive (2019/771), the Waste Framework Directive (2008/98 EC), the Waste of Electrical and Electronic Equipment Directive (WEEE Directive) (2012/19/EU), the EU Ecolabel, and Green Public Procurement. The different legislation regulates the EEE in different phases of life, hence, for instance, the Ecodesign Directive addressing the production stage and the WEEE Directive focusing on end-of-life.

When talking about repair, it is important to differentiate between repair and repairability. Whereas 'repair' focuses on product failure and the processes needed to return its functionalities, 'repairability' is a more in-depth study wherein products are considered through a broader scope beyond purely the most critical aspects (Matarin, Gasol, & Peiró, 2022).

To work toward extending the lifespans of mobile phones, it is important to implement a strategy called "slowing the loop" which can cause the positive effect that people use their devices for longer periods (IIIEE, 2021). If the repair of a mobile phone is an easy and economically viable option, there are incentives for people to continue using their device instead of replacing and buying a new one.

Similarly, Ertz et al. (2019), in their literature review on the repair sector, found that there are 2 fundamental strategies for creating closed loops: (1) *slowing the loop:* prolonging the useful life of products through design for long lifespans as well as life-extending measures such as repair, remanufacturing, refurbishment, reconditioning; and 2) *closing the loop*: reuse of materials through recycling.

Logically, under the current consumption patterns, the most convenient for companies and producers is to sell as many products as possible since that brings more income and revenue. Repair reduces the number of devices that can be sold. In this regard, Maitre-Ekern and Dalhammar (2016) have identified that companies have limited the repairability by means of different methods such as by restricting the availability of spare parts and not producing more after the expiration of the guarantee period, by changing the design of new models to be incompatible with older ones, and also by designing the engines and internal components in a way that special tools are required for disassembly. Such specialized tools are not easy to access for the consumers and the repairers manage to get imitations of the original tools.

Similarly, the IIEE & EEB (2021) found that according to the results obtained from surveying the repair sector in Sweden, 86% of the respondents mentioned that availability of spares is a barrier that complicates battery replacement, followed by 62% responding that necessary tools are another. In the same study, it was found that 42% of repairs are related to battery replacement. Therefore, one of the priorities that this new right to repair must be to encompass and guarantee, in a comprehensive way, repairability and replaceability of batteries because that can dramatically extend the lifetime of devices. In addition, when the spares are available and the design allows easy access, the time taken to replace the battery is minimum.

The cost of repair is a decisive factor for consumers. Previous research has found that consumers are willing to pay approximately between 19% and 30% for the repair compared to the replacement price of household appliances (Adler & Hlavacek, 1976; European Commission, 2018; McCollough, 2007, as cited by Ertz et. al, 2019). Consumers tend to consider the price of the products as the most important factor to repair seeing as more expensive products are more likely to be repaired (Richter et al., 2021) and conversely the cheaper products are less attractive to be repaired. Similarly, Milios (2021) found that customers were also discouraged from repairing their product instead of buying a new one because of the relatively low cost of new products compared to repair costs. In addition, the quality of products influences consumers in deciding whether a product is worth repairing (Milios, 2021). It makes no economic sense to invest in the continued survival of cheap, low-quality products and components, so reusing and remanufacturing low-quality products will not lead to a useful second life (Dalhammar, Milios & Richter, 2021).

Sonego et al. (2022) comment that the price of the products is an important factor that determines the decision of the consumers to repair the old one or replace them with a new one since for some products there is no marginal difference between getting a cheap one or repairing the broken one. In addition, for some products, the cost of repair is even higher than the cost of a completely new product (Sonego, er al 2022). Some jurisdictions in Europe have legally mandated that companies should provide spare parts to repair the products that they place on the market (PACE, 2019). If consumers have easy and cheap access to repair, they can decide to either repair or buy new, with the first option being preferable in all cases. Repair has to be considered in the consumption practices (López et al., 2021).

If repair is easy and cheap for the consumers, logically is more convenient for them and therefore this movement is being supported by citizens, consumers NGOs, and some politicians (Dalhammar et al., 2021) However, the implementation of repair is not simple (Dalhammar et al., 2021), because companies and producers have opposed it, and furthermore, the behavior towards repair has yet to be changed despite the support on the consumer side. Still, the majority of consumers believe it will be beneficial to both them and the environment because they will have easier access to repair discarded devices and hence have a lower environmental impact (Gulserliler, Atasu & Van Wassenhove, 2022).

Ertz et al. (2019) found that among electronics, mobile phones are the devices that are among those most commonly broken. In the same vein, according to a study on *Removable, Replaceable and Repairable Batterie*s developed by IIIEE & EEB (2021), in the repair of mobile phones, the most common cause was related to battery issues. In the same study it is commented that many producers change the batteries of the devices frequently, since every 2 -3 years new devices have different batteries. Moreover, there are new dispositions entering into force in 2022, such as the case of Spain, in which the producer is obliged to have available spare parts at least for the next 7 or 10 years after the introduction to the market of the products.

With similar findings, Bovea et al. (2017) comment that in Spain the most common cause to repair a phone was also related to battery change (34%). According to the findings of IIIEE & EEB (2021) on surveys to repairers of mobile phones, replacing a battery takes more than 20 minutes to complete the change process for all devices. The problem is that in many cases, the design of the devices doesn't allow for easy repair because opening the mobile phones can take more time than the time needed to change the battery. Enforcing the producer to provide batteries can extend the lifespan of mobile phones. This can prevent many devices from being disposed of before reaching the end of the use phase.

Commonly, batteries start failing before the rest of the components of the electronic products (Maire-Ekern & Dalhammar, 2016). Replacing a battery is often a part of repairing devices and can prevent disposal before the product has reached the end of its useful life (IIIEE & EEB, 2021). Battery replacement can also allow discarded devices to have a second life. In other words, spare part availability on the market at reasonable prices is an essential condition for the functioning and development of the repair sector (Milios, 2021).

Since battery issues are one of the major causes of repair, it will be reviewed briefly in this thesis to provide an understanding of the context of battery repairment and the barriers identified by the study on batteries developed by IIIEE & EEB (2021), in which the findings from the interviews with 3 refurbishing companies and 161 repairers of consumer electronics and LEVs are reported.

Table 3-1 'Challenges Faced By Repairers and Recyclers in Handling Non-Removable Batteries'

Challenges Faced by Repairers and Recyclers in handling Non-removable Batteries		
Battery repair	Inaccessible design	"Welded or glued battery casings that are not designed to be open make it impossible to conduct the process of repair which starts by opening the case… Impenetrable casings are increasingly common." (p. 12)
	Software blocks	"Software locks is the biggest barrier for the batteries which can be disassembled… more and more producers are using software locks to prevent refurbishment." (p. 12)
	Shortage of spares	"Planned obsolescence and supply chain shortages are two explanations for the reduced availability of battery packs or cells… many manufacturers change battery pack designs every 2-3 years." (p. 12)
Battery replacement		"Lack of available spare parts and tools, safety considerations, and software-related issues are significant barriers that make replacing a battery difficult." (p. 13)
Characteristics of frequently repaired devices and repair services		"Repairers mostly see high-value products in their shops" (p. 17) Battery replacement for the majority of repairers takes more than 20 minutes to complete the process for any device. However, the vast majority of repairers think that the time has increased in the past ten years. (p. 17-18). "Customers are not often dissuaded by the cost of replacing a battery." (p. 18)
Battery repurposing		Difficulty of removing batteries hinders the ability to reuse the excess energy storage capacity to give batteries a second life.

Battery collection	"Increasingly difficult to remove batteries are a key explanation for low battery collection rates at EOL. Time and the tools needed to remove integrated batteries affect the ability of consumers to remove batteries before disposal as well as the operational costs for waste sorting at recycling facilities." (p. 19-20)

Source: IIIEE & EEB (2021), Removable, replaceable and repairable batteries, Chapter 2, p. 28-39.

For products with low production costs and high secondhand availability, Right to repair may have negative environmental consequences due to the business model change. This can result in new production, decreased secondhand use, and thus an exacerbated environmental impact (Gulserliler et al., 2022). Of course, extending the lifetime of some equipment and devices can result in only positive environmental effects, however there are also some tradeoffs that have to be considered. For example, in some cases, improving durability of products with poor energy efficiency can be negative from a consumer perspective as the old products may use more energy and keeping them in use longer may add costs for consumers (Maire-Ekern & Dalhammar, 2016).

Moreover, in the *Ecodesign preparatory study on mobile phones, smartphones and tablets*, in Annex 11, an input to legislation is contained, in which a potential formulation of ecodesign requirements affecting the devices reviewed and researched in this thesis.

Concerning design for repair and reuse, one section described regulation considerations for the availability of spare parts. According to the legal input, from 1 xxx 2023, smartphones shall meet the following requirements:

Table 3-2 'Ecodesign Requirements for Smartphones'

From 1 xxx 2023, smartphones shall meet the following requirements:		
"(1) availability of spare parts"	"(a)Manufacturers, importers or authorized representatives shall make available to professional repairers at least the following spare parts, including required fasteners, if not reusable, for a minimum period from 6 months after placing the first unit of a model on the market until five years after placing the last unit of the model on the market, when present"	• Battery • Back cover or back cover assembly • Front facing camera assembly • Rear-facing camera assembly • External connectors • Buttons • Microphone • Speaker • Hinge assembly • mechanical display for folding and rolling mechanism.
	"(b)Manufacturers, importers or authorized representatives shall either make available to end users at least the following spare parts, for a	• Battery

	minimum period from 6 months after placing the first unit of a model on the market until five years after placing the first unit of the model on the market."	
	"(c)Manufacturers, importers or authorized representatives shall make available to professional repairers and end users at least the following spare parts, for a minimum period from, 6 months after placing the first unit of a model on the market until five years after placing the last unit of the model on the market."	• Display Unit • Charger
"(3) Maximum delivery of spare parts"	"(a) During the period mentioned under points 1(a) 1(b) and 1(c) the manufacturers, importers or authorized representatives shall ensure the delivery of spare parts."	Delivery time expected: Within 5 working days after having received the order.

Source: Ecodesign preparatory study on mobile phones, smartphones and tablets (2021)

The price of spare parts must be regulated since it heavily influences decision-making for consumers on whether to repair or purchase a new device, however, in some cases, there is little price difference between the spare parts and acquiring a new device and consequently, consumers are convinced by not to repair (Maitre-Ekern & Dalhammar, 2016). If more than one repair is required over the lifespan of the device, the cost of the spare parts can be even higher that the initial cost of the product (Maitre-Ekern & Dalhammar, 2016) contributing to normalizing the disposal behavior.

Several market conditions could significantly change some of the dynamics, and for that reason, there is also a need for new policies. Higher prices for higher quality would be beneficial as it would lead consumers to more careful consideration of their purchases and then the attitudes toward repair would change (Dalhammar, Milios, & Richter, 2021). One good practice that was identified regarding reparability is the ecolabeling in Austria of electrical and electronic equipment designed for easy repair (European Court of Auditors, 2021, p. 21).

Combining policies in a well-designed policy mix is important for success. As suggested by Dalhammar et al. (2019), in order to promote product repair, different policies can be applied, for instance:

- Through ecodesign rules that force producers to make products easy to disassemble, repair, and reassemble;
- Force producers to provide spare parts and repair tools at a reasonable cost;
- Reduce the Value Added Tax (VAT) for the repair sector;

- Provide information for consumers about the environmental impact of electronics and the subsequent benefits of repair; and
- Support do-it-yourself activities like repair cafes.

Some of the aforementioned policies proposed by Dalhammar et al. (2019) are already being implemented in some member states, such as the VAT reduction in Sweden and Austria for repair sector, whereas others are being discussed at the European Union level, such as forcing producers to make products easy to disassemble and repair or the obligation to provide spare parts. The latter, concerning spare parts, has been proposed recently in Spain, and is expected to enter into force soon. Environmental taxation can also be applied to enable VAT deductions to promote repair services (Milios, 2021).

3.3.2 Repairability Index

France became the first country in the EU to introduce the Repairability Index in 2021. The objective of this index is to inform consumers about the potential that certain electronics have to be repaired. This new policy has the potential to influence consumers' preference towards the most repairable devices.

As stated in the *Ecodesign Working Plan 2022-2024*, previous iterations have recognized specific products which could most benefit from ecodesign and energy labeling measures (European Commission, 2021). Smartphones have been included under the mandatory information requirement, together with laptops, televisions, washing machines, and lawnmowers. Other electronics are expected to be included in this mandatory requirement in the future. Under the new Right to Repair movement, there has been discussion about what information will be made available to consumers or to the independent repairer in order to make necessary fixes.

According to Right to Repair Europe (2022), the index assesses 5 criteria: documentation, disassembly, availability of spare parts, price of spare parts, and product-specific aspects. The aforementioned criteria are the most important when repairing, for instance, if the access parts turn out to be expensive, consumers will prefer to purchase new devices.

The Repairability Index can be a vital measure in incentivizing the purchase of products with a better environmental performance. Recent scientific research corroborates that consumer behavior is more likely to be affected by graded labels (e.g., the EU energy label) than by alternative designs. (European Commission, 2021). As it has been analyzed in previous sections of this literature review, energy labels are widely acceptable and have achieved strong results.

One recent Eurobarometer survey found that 93% of EU consumers recognize the energy label and 79% take it into consideration when buying appliances (European Commission 2021). If this type of informative labels proved to find success in the past, it can be expected that the same will occur with the repairability index and the expected durability index which will enter into force in France in 2024. Research shows that consumers tend to favor easily repairable products but that their willingness to pay (WTP) depends upon the product type and the way that repairability information is conveyed (European Parliament, 2022).

The fact that consumers can perceive, in a material way, the benefit of purchasing mobile phones with this type of label is a positive aspect of this policy. With a key aspect of the EU being the free trade of goods, it would be a problem if each member state had its own regulation on product design and composition (IIIEE, 2021). Such regulation would mean that products manufactured in one country could not be sold in another country. Thus, most product design policies are adopted first by the European Union and then applied unilaterally to all member states (IIIEE, 2021). France is the forerunner regarding the repairability index, and it is expected

that this will influence other member states, such as its neighboring country, Spain. In addition, the European Union has announced that this model of index is expected to be adopted across the region.

Dalhammar, Milios, and Richter (2021) evaluated existing rating systems, finding that lifespan labeling does in fact influence purchasing decisions, with products with longer lifespans being favored by consumers. On average, sales of products with a label advertising a longer lifespan than competitors increased by 13.8%, however it varied with the type of product (Dalhammar, Milios & Richter, 2021). In mobile phones, this label can cause an important change.

For the purpose of this thesis, there is a particular interest in the French repairability index because, as mentioned above, there are intentions to create a repairability index in Spain that is similar to France's, and the Ministry of Commerce is already working on its development.

Energy labeling as an example of a successful policy

According to the European Commission (2022), in their latest *Ecodesign Impact Accounting Report* (2020), energy saving from the 2020 EU regulation on ecodesign and energy labeling has achieved important reductions in energy use in the residential sector, including the electric and electronic equipment, which account for much of this use at the household level.

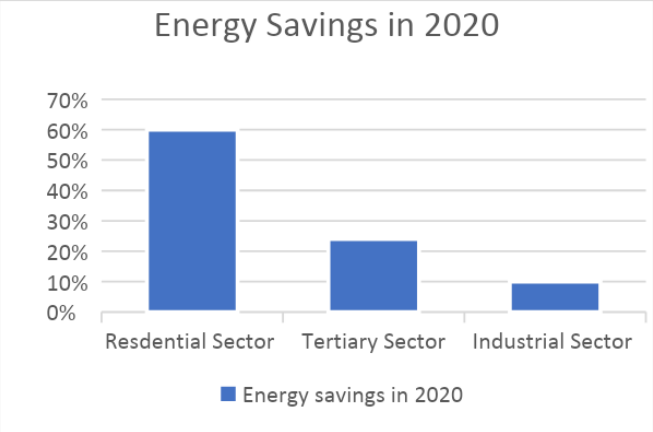


Figure 3-2 'Energy Savings in 2020 Per Sector'

Source: 'The Ecodesign and Energy Labelling Working Plan 2022-2014'

As can be observed in the figure above, the residential sector has achieved dramatic energy savings through the regulations on electrical and electronic equipment (EEE). In the first stages, the main objective was energy efficiency and a lot has been achieved on this front through the years. However, as technologies have been evolving and becoming mature, now the primary objective is achieving durability of the EEE.

Single market policies make it easier and cheaper for actors at all scales, from private citizens to governments, to contribute to the transition to cleaner energy sources and deliver on the EU's European Green Deal objectives, which include the Circular Economy agenda (European Commission, 2022).

The energy labeling policy has achieved great results since its implementation. Now that this aspect is better regulated, the current legislation needs to focus on the durability of the products.

3.3.3 Ecodesign

When talking about repairability, durability, reusability and upgradeability of energy products, it is important to talk about the Ecodesign Directive (2009/125/EC), which established the framework for setting ecodesign requirements for energy related products. This directive has greatly affected the production of electronic devices since it was first implemented. The directive provides the definition of "Ecodesign" in Article 2, which is written as follows: "Ecodesign" means the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle."

The current directive has a strong track record of providing benefits to producers, to consumers, and to the natural environment (European Commission, 2022b). In 2021 alone, the current ecodesign measures saved European consumers 120 billion euros. The benefits of ecodesign were observed by industrial players even prior to the implementation and enforcement of the directive. One of the first industry players that identified the potential environmental savings was Dutch electronics producer Philips, which began its first ecodesign initiative in 1994, long before many national policies (PACE, 2021). The directive regulates different energy products. However, due to the scope of this thesis, only mobile phones and these aspects regulated in the directive are reviewed in depth.

In addition, this directive has evolved through the years and, after a phase conducting preparatory studies, including the *Ecodesign preparatory study on mobile phones, smartphones and tablets* (2021), the European Commission has recently announced in March 2022 new proposals that build on the existing Ecodesign Directive. These new policies would dramatically expand the diversity of environmentally friendly products on the EU market and, in addition, make these goods more mainstream (European Commission, 2022).

In the waste management sector, the WEEE Directive has been in development since the beginning, when promoting collection and recycling was the primary focus. Following the WEEE Directive's implementation by the EU, collection and recycling systems were created. Great progress has been achieved in past years in the collection rates of many of the EU states, however, in other cases, some actions are still pending in order to improve. Nonetheless, the waste sector management continues to evolve, and new priorities have arisen as previous ones have been accomplished (depending on the country).

As mentioned by Puentes (2021), the Ecodesign Directive is an environmental policy instrument that employs a preventive approach, whereas previously the dominant environmental approach was focused on retroactively fixing the damage.

According to *the Ecodesign preparatory study on mobile phones, smartphones and tablets* (2021), the implementation of the Ecodesign requirements, as detailed in the policy options analyzed, are expected to affect sales of phones due to prolonged replacement cycles. Consequently, as described in the study, the combination of potential ecodesign requirements and energy labeling would place 36 million (26%) fewer phones on the EU market per year in 2030. Likewise, researchers from the International Institute for Industrial Environmental Economics (2021) concluded a similar figure. Regulating battery replaceability can keep 39 million devices from being unnecessarily replaced in 2030 (IIIEE, 2021).

Regarding ecodesign, according to the IIIEE (2021) in their Compendium about Circular Economy, 6 strategies might be chosen:

Table 3-3 'Six Ecodesign Strategies'

Ecodesign Strategies	
Strategy 1	**Design for attachment and trust** - This approach to Ecodesign encourages longer product lifespans because the user has formed an emotional bond and therefore is less likely to discard or replace it.
Strategy 2	**Design for durability** – In short, goods that are designed for durability and repairability are less likely to fail and thus less likely to be disposed of. However, a product's "durability" needs also to consider economic and aesthetic longevity and viability. For example, designing single-use packaging to be durable misses the priority for users, and it is thus illogical to invest in the cost and the material resource consumption associated with hardiness of these products.
Strategy 3	**Design for standardization and compatibility** – This strategy usually involves designing components to be "interchangeable and compatible with multiple products." These designs allow for repair and can extend the life of the products as "when compatible replacement parts are readily available products may be more easily refurbished or reused. This can also help reduce overall consumption as one product can be used for different purposes." One example would be using the same charger for multiple phones and tablets instead of each product type using a different charger shape.
Strategy 4	**Design for maintenance and repair** – "This design strategy extends product lifetimes by increasing the ease of product maintenance." Repair for many products is often time-consuming and in countries with high labor costs, it can oftentimes be more expensive to repair a product than purchasing a new one." Reducing the number of components in a product, or simplifying how parts are joined – for example by avoiding adhesives – can help companies decrease repair time and cost. And, it can also enable users to more easily repair things themselves. The availability of repair manuals and spare parts is of course also a key enabling factor "
Strategy 5	**Design for adaptability and upgradability** – "Here, allowance is made for future product modification… Technical updates such as the update of a computer with a new operating system allow products to adapt to technological change."
Strategy 6	**Design for ease of disassembly and reassembly** – "The design of products and parts so they can be taken apart and reassembled not only enhances the reparability and reusability of products and components, but also makes the products easier to recycle."

Source: Circular Economy - Sustainable Materials Management A compendium by the International Institute for Industrial Environmental Economics (IIIEE) (2021, p. 32-33)

As can be concluded from the 6 strategies proposed by the IIIEE (2021), the main objective is to extend the lifespan of the products, which, in this thesis, a special attention is placed on the lifespans of mobile phones. In policy as well as academic spheres, repair is repeatedly referenced as an "important strategy" for extending electronics lifespans and reaching circularity (López et al., 2021). Therefore, producers should design products for easy repair, maintenance, upgrade, refurbishment, and remanufacture (IIIEE, 2021). By lengthening the product's use phase, these strategies can contribute to reducing resource use in the production phase (IIIEE, 2021).

Government actors are vital to the development of circular design (PACE, 2021). Metrics for analyzing circularity based on criteria such as durability and recyclability must be used while taking into account the inherent tradeoffs between these qualities (PACE, 2021). These policy

instruments can be applied either as regulatory requirements or as economic incentives, including Extended Producer Responsibility (EPR) fees, rewards and penalties on taxation rates, or public procurement (PACE, 2021).

It has to be noted that the ecodesign requirements should not be applied to all products since some have more environmental impacts in the use phase than in production. As mentioned above, producers may face tradeoffs between durability and resource efficiency as often manufacturing of more robust products requires highest resource use (IIIEE, 2021).

Ecodesign regulation must not lead to excessive costs nor weaken competition between producers and must not pose an undue burden on consumers (European Commission, 2021). If circular business models and product repair become more mainstream, consumers can save money on their purchases (European Commission, 2022). Ecodesign requirements can reduce the cost of repairing mobile phones, for instance, by reducing the time spent servicing the device.

According to Puentes (2021), the challenges for ecodesign in the Circular Economy are the following:

1. The durability of products and other strategies against planned obsolescence,
    a. The legal penalization of programmed obsolescence,
    b. The normative reform regarding consumer protection,
    c. The enactment of ecodesign legislation on durability,
2. The Right to Repair for goods, and
3. The product and infrastructure capacity for reuse and recycling.

3.3.4 Fiscal Incentives for the Circular Economy

Because fiscal policy instruments affect costs and prices, they can prove very effective at guiding markets and influencing the behavior of economic actors (Vence, 2022, p.165). Economic agents, such as the OEMs, often base their actions according to what brings in money or according to what makes them earn money or save money, and therefore, the incentive can use this understanding to foster certain behaviors.

Environmental fiscal policy is directly aimed at creating financial incentives for economic actors to engage in positive environmental behaviors. These objectives manifest in public spending, subsidies, tax instruments, and other tax expenditure methods (e.g. exemptions and benefits) (Vence, 2022, p. 166). Environmental taxes include levies, which penalize those activities that cause environmental and/or social degradation (Vence, 2022, p. 167). According to the *Polluter Pay Principle*, this tax should apply to all producers that place low quality products on the market and to those that do not adhere to ecodesign requirements. Conversely, those producers who follow ecodesign requirements should be rewarded with less levies or with a tax deduction.

To meet the objective of improving resource efficiency in the broader economy, the VAT rate on repairs should be minimized to help local shops be able to offer repair and maintenance services (Milios, 2021). However, despite these theoretical benefits of low VAT rates for repair and reuse, few actual examples of implementation exist (Milios, 2021).

Puentes (2021) notes that the *2015 Action Plan on Ecodesign* amended the EPR regime to set a fiscal incentive for producers to design products with easier repair, reuse and recycle. Specifically, it was proposed to create a modulation of the financial contribution made by producers to collective systems based on the costs of the end-of-life phase of the products.

For the Circular Economy, researchers have reviewed tax incentives that can trigger or encourage taxpayers to have more environmentally friendly behaviors. Milios (2021), for

example, researched (1) How can a fiscal policy framework for CE be constructed to improve resource efficiency across the lifecycle and what instruments would be appropriate to include? and (2) What is the potential effectiveness of a fiscal policy framework for a Circular Economy?

The prevailing tax system favors activities of a linear economy over those labor-intensive aspects of the Circular Economy, such as repair, maintenance, reuse, or remediation services (Vence, 2021, p. 177). Hence, there is a need for new reforms and amendments to the fiscal codes at the EU and national levels to encourage these activities that benefit many sectors.

3.3.5 The Fight Against Programmed Obsolescence

Looking back, many products, both for personal and professional use, were more durable than today, and consumers were more accustomed to repairing and fixing their devices (Dalhammar, Milios & Richter, 2021; Slade, 2007). The premature disposal of LIBs and electronic devices has profound sustainability implications, across the environmental, social and economic spheres (IIIEE & EEB, 2021).

Programmed obsolescence is more than the manipulation of algorithms to create a scheduled failure of devices, particularly electronics (Vence et al., 2022, p. 29-30). In addition to this technical planned obsolescence, companies often create social obsolescence through aggressive marketing to consumers (Vence et al., 2022, p. 29-30). Together, these business strategies contribute to GDP growth (Vence et al., 2022, p. 29-30).

As reported by European Environmental Agency (2021) in the *Electronic Products and obsolescence in a circular economy* the different product obsolescence types consist of:

1. Absolute obsolescence: functioning failures which are mainly influenced by product design. In this case, the actual lifetime is the designed lifetime.
    a. Mechanical obsolescence: when the failure is caused by functional issues of the material components.
    b. Incompatibility obsolescence: when the functional failure is due to a lack of interoperability between the software and/or hardware.
2. Relative obsolescence: The abandonment of a functional product. Unlike absolute obsolescence, the actual lifetime does not reach the designed lifetime. Disposal, thus, is the result of both the product's design and the consumer's behavior. The decisions by consumers are, of course, influenced by marketing. Relative obsolescence includes other types:
    a. Psychological obsolescence: also known as style, cosmetic, or aesthetic obsolescence, occurs when the user replaces their product based purely on a desire for a new item rather than any functional failure of the old item.
    b. Economic obsolescence: when the user replaces their product because it is cheaper than repair or upgrade.
    c. Technological obsolescence: when the user replaces their product because the new product offers better quality of functionality.

Both relative and absolute obsolescence can lead to premature obsolescence. If this is intentional, and the product is designed from the beginning to have a shorter lifespan or consumers are encouraged to repeat purchases, scholars refer to it as "planned" or "programmed" obsolescence (European Environmental Agency, 2021).

This topic can be approached at either the EU level or the national level. In the EU context, as stated in the *Communication from the Commission to the European Parliament on making sustainable products the norm (2022*) the proposal on *Regulation on Ecodesign for Sustainable Products* will prohibit multiple practices that cause premature obsolescence, including planned obsolescence. However, since criminal law is applied at a national scale, it depends on each member state to determine the criminalization of this practice. In this regard, the initiative taken by the French

administration on these practices has influenced other EU members. Because they implemented penalties as early as 2015, French policy has been considered a success against such obsolescence because it has been the first of its type at the European level. Italy has established levies on obsolescence. In spite of the progress, more policies and actions still have to be taken to end this practice and assure the durability of products.

Dalhammar, Milios, and Richter (2021) found the main reasons for obsolescence, as explained in the following table:

Table 3-4 'Main Reasons for Obsolescence'

Main Reasons for Obsolescence	Possibility to be Tackled Under Right to Repair Proposals
"Psychological or style obsolescence - obsolescence driven by marketing campaigns, etc."	Psychological obsolescence is a complicated type of obsolescence since it is needed to change the social behavior regarding repair and secondhand use.
"Product failure or breakdown (often due to specific components)"	The durability index can result in an effective measure.
"System obsolescence"	The durability index can result in an effective measure.
No access to - or expensive - spare parts for repairs	Under the new ecodesign requirements spare parts will be available.
"Repair services are expensive or inaccessible or generally considered less desirable than buying a new product with guarantee."	As one of the benefits of ecodesign the devices will be easier to repair. In addition, the easy access to spare parts will reduce the price of repairs.
"Technological or functional obsolescence"	N/A

Source: First column (Richter, Dalhammar, & Milios, 2021, p. 34), Second column (own elaboration)

To conclude, Puentes (2021) notes that programmed obsolescence is one of the primary challenges for the Circular Economy. This type of practice is one of the strategies that producers use to influence the behavior of the consumers and make them purchase more products, which can translate into more income and revenue for the producer. Premature obsolescence may benefit the economy, but it causes environmental and social issues as it can lead to excess natural resource use, an increase in credit purchases and thus consumer debt, and a dissatisfaction with the quality and life-cycle of the products (European Environmental Agency, 2021).

3.3.6 Extended Producer Responsibility (EPR) as an Instrument of Environmental Law

As noted by Dalhammar, Milios, and Richter (2021), modulated fees in EPR schemes have the potential to provide incentives for ecodesign. In order to provide incentives, there is a need to raise the bonus/malus and to apply similar types of fees across the continent to more profoundly influence OEMs (Dalhammar, Milios & Richter, 2021).

From a different perspective, in the Spanish context, De la Varga (2021) claims that the Producer Responsibility Organizations (PROs) (in Spanish SCRAPS) have focused mostly on waste and its management, prioritizing recyclability and valorization while largely ignoring prevention. Similarly, Dalhammar (2021) argues that EPR schemes lack sufficient incentives for

transitions to higher levels of the Waste Hierarchy, for example, designing for longer lifespans to prevent waste, or, making collection and repair more accessible to increase reuse. In the same vein, researchers from the International Institute for Industrial Environmental Economics (2021) claim that the most difficult challenge for making EPR a central instrument in the Circular Economy is the lack of legislation to guarantee clear incentives for the producer who implements ecodesign (IIIEE, 2021).

Without incentives, there is no direct benefit to smartphone producers to design for circularity because there is no direct link between producers and recyclers, and thus the value of the efforts is lost (IIIEE, 2021). Hence, in situations like those mentioned above, a well-structured EPR scheme can play a crucial role in promoting circularity through collaboration between different actors.

EPR policies allocate responsibilities to producers and other actors for the EOL management of their products while also intending to provide incentives for ecodesign (Dalhammar et al., 2021).

3.3.7 Pre-market Producer Responsibility (PPR)

This concept will be explored only briefly in this thesis, due to the limitations of time and scope. However, pre-market producer responsibility (herein, PPR) is a relatively new concept that will be crucial in reaching Circular Economy objectives and especially in regard to ecodesign.

A pro-circular evolution could come from specific and strong legislation on products introducing the "pre-market producer responsibility", which aims to ensure that the producer is responsible for the impacts to the environment, human health and social justice issues of the product (s) placed on the market (Maitre-Ekern, 2021). It would not be based on financial responsibility and the polluter pays principle, but on the duty of care derived from the precautionary principle (De la Varga, 2022). Only if this principle is applied appropriately and the governments place stringent requirements to ensure its compliance, can positive results be achieved.

Maitre-Ekern (2021) argues that producers should care about the products that they place on the market and ensure activities for repair and reuse. Under PPR, ecodesign has to be considered (Maitre-Ekern, 2021), and thus PPR is a largely preventative policy instrument. As the needs for waste management have been evolving, the attention on preventative measures has to increase. PPR should make producers responsible for taking measures to limit the environmental impact of their products and extend their lifetime in accordance with the CE objectives prior to ever placing them on the EU market (Maitre-Ekern, 2021).

To conclude, compliance with certain mandatory obligations before placing products on the market is an important strategy for waste management as prevention is the best approach. Therefore, Maitre-Ekern (2021) proposes 4 examples of PPR that are aimed at extending the lifespan of products, which are aligned with the R2R proposals:

1. The provision by producers of the information about the aspects related to expected lifetime, disassembly characteristics, repairability, and materials contained. Without this information, the products should not be permitted on the market, and therefore, this measure is named by the aforementioned researcher: "no data, no market".
2. The "availability (and affordability) of spare parts", which is one of the most important aspects of extending the lifespan of electronics, and in addition, can lead to more repairs.

3. The "take-back scheme for repair and reuse", which can contribute to extending the lifespan of electronics that can be repaired, refurbished, and prepared for reuse. In addition, this can help to collect broken devices that do need to be recycled.
4. The establishment of a "second-hand and reuse section in the store", since typically consumers prefer to purchase new devices. Hence, with this strategy, second-hand goods can be more visible to consumers and can make this product more mainstream.

3.4 Different Points to Consider in Different Stakeholder Groups

In the repair sector there are multiple actors involved, and each one is critical to its functioning. In the following sections, the role of each of these stakeholders in the repair sector is reviewed and analyzed. There are those stakeholders that have more power to influence more than others.

3.4.1 Consumers

3.4.1.1 Consumer Behavior Toward Repair

For some, a "good deal" may indeed mean buying durable, high-quality products, but for most people today, a "good deal" simply means being able to purchase as many products as possible at the lowest price (Maitre-Ekern & Dalhammar, 2019). Yet, there are indications that the number of product repairs has decreased in recent years and that throwing away a broken product instead of repairing it is becoming normalized.

The quality of the products influences the behavior of the consumer; for instance, if they buy higher quality goods, they would prefer to keep using them and extend their lifespans by repairing them. Therefore, it is important to regulate producers to make them comply with the ecodesign requirements that are fundamental to higher quality products with improved repairability and durability. Maitre-Ekern and Dalhammar (2019) conclude that there is a need to regulate more products and materials. Legislation is necessary to create incentives for producers to design durable products and also, on the consumers' side, to promote sustainable choices. (Maitre-Ekern & Dalhammar, 2016). The products that are placed on the market by the producers need to be regulated (Dalhammar et al 2022).

Encouraging people to extend the lifecycle of products rather than disposing of them is a complicated task that requires the implementation of a good policy mix. Incentives have to be created, as well as making the procedure easy and accessible to consumers. Sonego et al. (2022) found in their literature analysis that the majority of consumers do not repair: 90% for household appliances in Spain (Bovea et al., 2017; Pérez-Belis et al., 2017, as cited in Sonego et al., 2022) and 66% for mobile phones in Spain (Bovea et al., 2018-a, as cited in Sonego et al., 2022). Sonego et al. (2022) concludes in their study, on *Consumer practices and institutional initiatives,* that it is necessary to strive to motivate the consumers to repair through different strategies that can promote attachment instead of consumerism. Most of the participants surveyed in Spain by Bovea et al. (2017), when they stopped using a small ICT equipment, answered that they disposed of it, even if it was still in functional condition and only 13% because it was broken. However, despite the low rates in repair of small ICT, laptops, mobile phones, and tablets were the most repaired (Bovea et al., 2017).

It is important to design policies intended to change the behavior and make repair easier and cheaper, otherwise the same practices will continue existing and the stream of e-waste won't be reduced.

3.4.2 Repairers

The right to repair, on the one hand, seeks to encourage consumers to repair their devices by their own means, with easily repairable designs, access to spare parts, and public information on

how to repair. On the other hand, right to repair also seeks to facilitate repair by professional technicians and independent repairers, which is similarly important to consumer behavior as a further step toward repairability (European Commission, 2021). Understanding and preparing this sector is one the first steps toward increased accessibility of repair.

Consumers with a broken device are faced with four options: "1) contact the seller, the OEM's repair division or authorized repair service provider; 2) approach a local, independent repairer; 3) perform the repair themselves; 4) discard and replace the product", according to a *Deloitte Study on social economic impacts of increased repairability*, cited by Dalhammar, Milios and Richter (2021).

According to the literature that has been reviewed, two types of repairers have been identified. First are the official repairers, who are hired by the producers and distributors to work in service and repair at official stores which facilitate the access to information, original spare parts, and tools. This category of repairers is not affected by intellectual property issues and legal barriers because they work directly on the producer side, and it is convenient for the companies to provide all the tools and information needed to carry out the repair.

The other type are the independent repairers, who are technicians that work in medium and small local business. This category is faced with many barriers created by the producers, such as limited access to spare parts or information.

Svensson et al. (2018) notes that, when talking about repair services, there are "open" and "close" access to repair services, hence in the former, customers can decide who will perform the repair services, and in the latter, the customers can access only those repairer services that the producer offers. A recent study carried in Norway by Ertz et al. (2019) found that only 28% of phone repairs conducted by private individuals were successful, compared to 55% by professionals. The cost and quality of the devices is an important reason to fix electronics (Ertz et al., 2019).

Since the repair sector is not very competitive, it is important to foster these activities through fiscal incentives. It would be more attractive and economical to repair products if they are designed for it and if there is appropriate tax relief (Milios, 2021), and the new right to repair legislation has the potential to achieve these objectives by influencing the sector. Strengthening the repair business would also, of course, increase employment in the European Union.

Since the tax base and application of proposed tax reductions for repair services have so far been limited, and so their potential effects have not yet been fully assessed, and additionally it would include an extra administrative cost (Milios, 2021). Similarly, in an interview carried out by the researcher with an academic researching the topic, he mentioned that tax deductions for the repair sector require further analysis since the administrative procedure to establish it can be complex and requires political will.

Whether a consumer is confident that the repair will be performed correctly, and consequently extend the product's lifespan, may affect the decision to repair or not to repair (Ertz et al., 2019). Researchers have begun to examine how to increase the number of repairs. For instance, a bike repair company proposed that certification among workshops could be a good solution since customers would be informed about the quality of the repairs (Milios, 2021). While the aforementioned proposal was made by a repairer of a different product, this certification can be replicated in the small ICT repair sector. In France, some repairers will be able to be certified under the extended producer responsibility systems by the EPR scheme (Dalhammar et al., 2022; Ecosystem, 2021). As mentioned above, consumer expectations of the quality of the repair can influence their decision to repair (Ertz et al., 2019). What can be the subject of future research is the implementation of this certification in different schemes and countries.

Repair Vouchers

One good example of a policy intended to foster repair and benefit the sector can be observed in Austria, where the identification and registration of professional repairers through local networks can make access easier for consumers (Almén et at., 2021; Lechner et al., 2021; Piringer & Schada, 2020).

In the two biggest cities, Vienna and Graz, these networks have been established and receive money from the municipal treasury (Almén et al., 2021; Lechner et al., 2021; Piringer & Schada, 2020). In Vienna, vouchers can only be redeemed with members of the network that fulfill the acceptability requirements (Almen et al., 2021; Lechner et al., 2021; Piringer & Schada, 2020). Likewise, the municipal government in Graz offers a subsidy of 100 EUR as maximum for repairs, which is offered once a year per household (Almen et al., 2021; Lechner et al., 2021). The amount of money covered by the voucher can be considered adequate for some ICT, since, for instance, Bovea et al. (2017), in their survey *on consumers attitudes in Spain,* found that in 95% of ICT repairs, the cost did not exceed 100 EUR, and in 54% of the cases, the repair cost was less than 50 EUR.

Dalhammar et al. (2022) suggest that under this modality, for the municipality to be able to afford the repair vouchers, companies that put products in the market should pay levies to a fund which is designated to their financing.

3.4.2.1 Information Provided to Repairers

In the *Ecodesign preparatory study on mobile phones, smartphones and tablets (2021)*, Annex 11 contains proposals of several additions to legislation which describes a potential formulation of ecodesign requirements affecting the devices covered in this thesis. One of the articles proposed, refers to the information that the producers have to provide to the professional repairs:

Table 3-5 'Information Provision Obligations'

"(2) From 6 months after placing on the market the first unit of a model and until seven years after placing the last unit of the model on the market, the manufacturer, importer or authorized representative shall provide access to the repair and maintenance information to professional repairers"	"(e) The repair and maintenance information shall include: • the unequivocal appliance identification; • a disassembly map or exploded view; • wiring and connection diagrams, as required for failure analysis; • electronic board diagrams, as required for failure analysis; • list of necessary repair and test equipment; • technical manual of instructions for repair; • diagnostic fault and error codes (including manufacturer- specific codes, where applicable); • component and diagnosis information (such as minimum and maximum theoretical values for measurements); • instructions for software and firmware (including reset software); • information on how to access data records of reported failure incidents stored on the device (where applicable); • software tools, firmware and similar auxiliary means required for full functionality of the spare part and device after repair, such as remote authorization of serial numbers."

	"(f) third parties shall be allowed to use and publish repair and maintenance information covered by point (e) once the manufacturer, importer or authorized representative terminates access to this information after end of the period of access to repair and maintenance information."

Source: Ecodesign preparatory study on mobile phones, smartphones and tablets (2021, p. 586-587), Annex 11

In the legal inputs for the ecodesign requirements, in the *Ecodesign Preparatory Study* (2021), it is considered that the websites of producers, importers, or authorized representatives must indicate the process for professional repairers to register for access to information. To accept such a request, these producing actors may require the professional repairer to demonstrate that the (s)he has the technical competence to repair mobile phones, coverage by insurance, and a payment of fees for the access to the repair and maintenance information or for receiving regular updates.

3.4.2.2 Reuse and the Secondhand Market

Reuse constitutes a waste prevention strategy in which, instead of becoming waste, the product is employed by a second user in the same manner as it was intended. This is distinguished in the Waste Hierarchy from preparation for reuse, which applies to reusable products that have entered the official waste stream (Dalhammar et al., 2021). As it has been established in the Waste Hierarchy, reuse is always better and should be preferred over recycling. The value of second-hand products is higher than the individual components and higher than the materials alone (PACE, 2019).

Reuse markets obtain devices from EPR schemes, such as in the case of Spain, where preparation for reuse targets have been established. Previously, the main objective when collecting WEEE was recycling, however, now reuse is the priority whenever possible. Under the recycling targets there is no incentive to take care of the devices collected since they will be dismantled in the process, and therefore, having reuse targets can incentivize PROs to better care for the devices collected for evaluation, repair, or refurbishment (Dalhammar, Milios & Richter, 2021a).

It is important to gain the confidence of second-hand sellers and buyers since its common that consumers prefer new devices since its frequently assumed that "new is better". The quality of products can define their popularity in the secondhand market, as it was found through interviews to PROs conducted by Dalhammar, Milios, and Richter (2021).

If ecodesign allows for more repairability on the products, it is not only the repair sector that can benefit, but also the secondhand and refurbishment sectors (European Parliament, 2021). To increase confidence on repaired equipment, a quality label can increase the willingness to buy secondhand products as well as provide fiscal incentives for repairs (Milios, 2021).

Purchasing secondhand or remanufactured products should always be a priority instead of buying new (Maitre-Ekern & Dalhammar, 2019). However, under the current consumerist economic model, the opposite behavior is more common since the priority is to have the newest goods. Of course, there have to be special considerations for certain products since buying secondhand products does have tradeoffs, for instance, those products that are often more energy-intensive than a new one, and therefore may have a larger environmental impact (Maitre-Ekern & Dalhammar, 2019). However, in the case of mobile phones, as mentioned in previous

sections of this thesis, the major impacts are caused during the production phase due to the extraction of the materials used in its components.

One of the barriers that must be solved in order to foster the growth of the secondhand market of small ICT is the personal information and data stored in the memory. For instance, Bovea et al. (2017) found that, in Spain, there is a tendency to store this device at home. Similarly, the European Recycling Platform Spain (2020), informed in their annual report that small ICT is the category with lowest collection rate, but this trend is not unique to Spain. To avoid this tendency, the information has to be easily transferred to another device or cloud. Electronics producers need to provide the facilities for consumers to ease the transfer of data and guarantee a safe data cleaning (PACE, 2021). Along the same lines, Carretero (2015) states that the preparation process for the reuse of WEEE should include the following phases: an electrical safety test, a function test, the deletion of personal data on computer and telecommunications equipment, the extraction and updating of software, repair, cleaning, and preparation for sale and labeling.

Another barrier for the purchase of secondhand ICT is psychological obsolescence. Even if the device functions correctly, the desire to acquire new devices is often too strong (European Environmental Agency, 2021). Fashion trends can influence the decision of consumers towards second products (Dalhammar et al., 2021). Striving to have the latest devices in the market can be a factor in the behavior of consumers since it is often associated with success and a particular social identity (López et al., 2021; Cox et al., 2013). Conversely, in Western consumerist society, having an outdated product is not well perceived socially and can thus lead to negative emotions (López et al., 2021; Cox et al., 2013).

In the reuse market of electronics, the products with higher profitability are the ICT, and this can allow retailers to offer warranty that can go from 1 to 3 years, in the best-case scenario (Dalhammar et al., 2021). This is favorable for this sector since the secondhand buyers can feel confident buying this type of devices.

3.4.3 Producers

3.4.3.1 Intellectual Property

In the current economic model, the main business for producers and retailers is the sale of new products and so these actors strive to not sell repairable devices which can turn out to be less profitable (Maitre-Ekern & Dalhammar, 2019). In the linear model, the major source of profit for OEMs is selling goods, and so producers have used different strategies to hinder reparation and access to it.

Industrial and intellectual property has been one major obstacle for the fight against planned obsolescence as well as for the repair movement (Vence et al., 2021). Recent regulations on product design have concerned producers (Gulserliler, Atasu & Van Wassenhove, 2022). Therefore, they have practiced intense lobbying against the right to repair and have sought protection for industrial property rights in different ways (Vence et al., 2021). In the United States, producers have found loopholes to circumvent the rules (Dalhammar, Milios, & Richter, 2021).

The barriers to access to information and the lack of availability of spare parts have obstructed repair (Dalhammar et al., 2021). In their analysis of *Business model choice under right to repair,* Gulserliler et al. (2022) found that cloning is more likely if information about the design is provided publicly. Additionally, innovation can be stifled because the competition also benefits from latest advances made by the proprietaries of patents (Gulserliler et al., 2022).

Likewise, the new generations of products must compete with older generations in the secondary market (Gulserliler, Atasu & Van Wassenhove, 2022). Producers are concerned about potential product cannibalization that reused goods can cause (Dalhammar et al., 2021).

A few years ago, in the European Parliament (2016), there was (2016) tension between efforts aiming to accelerate innovation and those aiming to promote the Circular Economy, as one negative economic effect of lifespan extension is decreased technological advancement.

Companies have sued independent repairers that have used unofficial spare parts or obtained original spare parts by means of harvesting old devices. One major and famous case is *Apple vs Henrik Huseby* in Norway which started because the local repairer used refurbished screens that were illegal copies (Right to Repair, 2020).

3.4.3.2 New Business Models

There are authors who argue that neoliberal environmental governance has to be reconsidered to advance the Circular Economy (Flynn Hacking, 2019, as cited in Vence et al., 2021, p.68). For instance, instead of focusing on the number of products sold, framing a service *as* the product (European Commission, 2022) can make the shift to different business models. This effectively means that to promote circular business models, companies have to be guaranteed profitability and attractiveness to consumers (European Commission, 2022).

In the business model in which the value is sold as a service, operational costs to extend the lifespan of electronics have to be considered such as monitoring, maintenance, repair, refurbishment, and testing (PACE, 2021; Circle Economy, 2018). Leasing can protect intellectual property and help to avoid the share of proprietary information, thus limiting the competition from the secondary market and third market clones (Gulserliler, Atasu, & Van Wassenhove, 2022).

Many current societies have been formed in such a way that consumption is preferred over durability as it is easier to replace products. However, it is important to take into consideration the alternatives that have been proposed and researched to support and reinforce the transition from linear economies to more circular economies. Circular business models are designed with resource efficiency at the core so that the company can create and capture value in a more sustainable way (European Commission, 2022). Due to the scope of this thesis, service-based business models are only reviewed briefly, with special emphasis placed on repair services.

Improved product durability will, however, result in decreased numbers of units manufactured and sold by companies, and thus decreased turnover (Fernandez, 2015). New models have to be explored to obtain the maximum revenue and offer different types of services. As Fernandez (2015) notes, the term 'servitization', originally used by Vandermerwe and Rada (1988), refers to the process of creating value by adding services to products. With servitization, new value propositions are defined for customers that include the product as well as a service(s) associated with said product (Fernandez, 2015). In the servitization business model, one of the phases includes services on the products that extend its useful life.

Through designing for the replacement of critical components, the product can be reconditioned, that is, returned to its original condition at the time of being placed on the market (Fernandez, 2015). Similarly, extension services might instead guarantee monitoring services so that producers can intervene to prevent technical failures (Fernandez, 2015). While servitization results on fewer manufactured products, by combining products with associated services, companies report higher income (Fernandez, 2015).

This new business model can prevent all the intellectual property barriers that currently exist in the market and would increase rates of repair and extend product lifespans, for example, of smartphones due to the fact that spare parts will be available for registered repairers.

For instance, in some European countries, including Finland, new business models are being explored in the public sector and not by private companies, wherein the municipality rents electronic equipment out in order to prolong its lifespan and increase the utilization rate (Finnish Ministry of the Environment, 2018).

Similarly, Gulserliler et al. (2022) conclude that companies might opt for business models, such as leasing, which allow them to retain ownership over the products while also responding to pressure from Circular Economy advocates for non-ownership and the associated intellectual property risks of the right to repair. Instead, it is profitable for businesses to ensure that the products that are incorporated into the service are durable and easily repairable as it reduces their need to spend money supplying new products (European Commission, 2022). Thus, transferring ownership to the company through servitization can be an effective way to promote a more circular economy.

According to the *Preparatory Study on Ecodesign* developed by the European Commission (2021), some OEMs have already begun to emphasize earning revenue through services on the devices themselves. Economic activities related to a longer lifetime for products (maintenance, repair, rental services, etc.) are used in many other industries. This scenario provides producers with the control over their products(s) throughout the use and end-of-life phases and creates leverage to optimize the Waste Hierarchy (IIIEE, 2021).

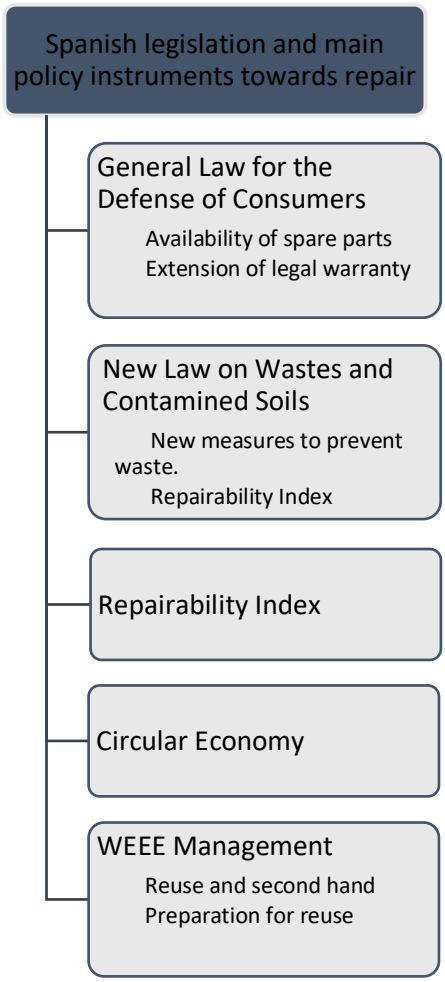
Current leasing models, where monthly contracts (e.g., for smartphones or televisions) allow consumers to access the most up-to-date technology, even if the products have short lifespan and high upfront cost (PACE, 2019).

3.4.4 Main Spanish Legislation and Policy Instruments To support Repair

Spain has passed legal initiatives intended to adopt the right to repair proposal and promote repair and reuse, to achieve the environmental goals and objectives established in the Circular Economy Spanish Strategy and Circular Economy Action Plans in which the prevention of waste is one of the most important aspects included and addressed. For that reason, this section will analyze the most relevant and important legislative changes that will influence the repair sector.

The aspects reviewed in this section are covered in the following diagram:

Figure 3-3 'Diagram of the topics of interest in Spanish legislation and policy instruments'



Source: Own elaboration

3.4.4.1 General Law for the Defense of Consumers

Spain has followed the circular economy proposals and regulations when the Royal Decree 7/2021 adopted the Directive 2019/770/UE and 2019/771/UE in which a reform of the services post-sale was introduced to extend the time in which the spare parts must be available to increase the lifespan of consumer goods. Prior to the reform, the time mandated in Spain was 5 years and now it is 10 years (art. 127 bis, *General law for the defense of consumers*).

This new reform can be considered positive since it is an important step in achieving objectives set in the Circular Economy Plan. The sustainability purpose of this legal provision is observed in the extension of the use phase of products through enhanced repairability. Ultimately, the legislation is intended to regulate the relationship between consumers and sellers. An extended legal warranty can incentivize customers to repair, and thus consumer preference for repair can be achieved if a reversal of the proof is not on their side (Maitre-Ekern & Dalhammar, 2016).

Other product types beyond electronics were included in the obligation to provide spare parts. Regarding the new regulation for spare parts, there have been critics of this legislation due to its ambiguity in the products regulated. Avilés (2021) argues that there is a legislative distortion in this new reform and that the Spanish legislation adopted the directives in an inharmonious way because the plans consider all goods without any differentiation on the category or nature of the products or devices. This is in part because the EU regulation is based on studies of the ecological design of each product, where they have opted to separate those goods or devices that must be considered as “priority” to individually adopt their respective measures".

The period in which the spare parts must be available depends on the type of products in the European Union regulation, hence the obligation varies between 7, 8 and 10 years, whereas in Spanish regulation, the obligation is 10 years without any differentiation and without any special consideration for products that don't require energy in the use phase (Avilés, 2021).

In the words of Maitre-Ekern and Dalhammar (2019), "consumers cannot keep being considered merely as the vulnerable party that needs protecting, but as an agent of change, whose behavior will make a difference in the struggle for sustainability". The access to spare parts and the ease of repair can influence the behavior of consumers and can help to extend the lifespan of a device.

3.4.4.2 The Circular Economy

Spain is implementing the Circular Economy Spanish Strategy to set the bases of new models of production and consumption of products in which its value stays for longer in the economy. In addition, this country is aligning its policies with those of the European Union and the European Green Deal. Every 3 years, a different action plan will be published and followed to achieve the objectives.

Table 3-6 'Circular Economy Spanish Strategy'

Circular Economy Spanish Strategy
• "Reduce by 30% the national consumption of materials in relation to GDP, taking 2010 as the reference year. • Reduce waste generation by 15% compared to what was generated in 2010. • Reduce the generation of food waste throughout the food chain: 50% reduction per capita at the household level and retail consumption and 20% in the production and supply chains from the year 2020. • Increase reuse and preparation for reuse up to 10% of municipal waste generated. • Improve efficiency in water use by 10%. • Reduce the emission of greenhouse gases below 10 million tons of CO2 equivalent."

Source: (Spanish Ministry for the Ecological Transition and the Demographic Challenge 2021)

Table 3-7 'Action Plan for the Circular Economy'

Action Plan for the Circular Economy
• Reinforcement of the legal framework for the management of EEE • Foster a database that contains the information of the center of preparation for reuse to extend the useful life of the wastes and prepare for a second use. • Evaluate the possibility of establishing a specific system to collect mobile phones and other electric and electronic equipment that contain high content of strategic raw materials • A strategy will be implemented to enhance traceability of WEEE • Actions aimed at improving the labeling of products in order to offer information in a more practical and simple way, detailing their "environmental footprint", their energy efficiency, their resistance and durability characteristics, their upgradeability or the availability of spare parts and their ease of repair. • Loans to support members of the industry that support and implement policies on access to information of the product to ease its reparation. Ecodesign compliance is also applicable.

Source: (Spanish Ministry for the Ecological Transition and the Demographic Challenge 2021)

The Circular Economy Spanish Strategy also poses a challenge to combating planned obsolescence in the introduction of CE, emphasizing the intention to concentrate efforts at the

beginning of the chain: in the design phase with product durability, combating planned obsolescence, and promoting servitization, as well as with the reuse, recycling and reprocessing of the components (De la Varga, 2021).

3.4.4.3 Spanish Law on Wastes and Contaminated Soils

In April of 2022, the final version of the law was published in the official gazette after a process of consultation and modification. Within Article 18 there are several provisions regarding the prevention of waste including some that are applicable to the electronics, as listed below:

Table 3-8 'Provisions Regarding the Prevention of Waste'

"1. To prevent the generation of waste, the competent authorities will adopt measures which purposes will be, at least, the following:"	a) "Promote and support sustainable production and consumption circular models"
	b) "Promote the design, manufacture and use of products that are efficient in the use of resources, durable and reliable (also in terms of useful life and absence of premature obsolescence), repairable, reusable and upgradeable."
	c) "Identify the products that contain fundamental raw materials identified by the European Commission, in order to prevent them from becoming waste."
	d) "Encourage the reuse of products and product components, among others, through donations, and the implementation of systems that promote a repair, reuse and updating, in particular for electrical appliances and electronics, batteries and accumulators, textiles and furniture, packaging and materials and products of construction."
	e) "Promote, when necessary and without prejudice to property rights intellectual and industrial, the availability of spare parts and tools necessary, instructions and manuals, technical information or other instruments, computer equipment or programs that allow repairing, reusing and updating products without endangering its quality and safety, taking into account the obligations established at European Union or national level on spare parts available for certain products."

Source: Spanish Law on Wastes and Contaminated Soils, Article 18

In addition, paragraph 9 of Article 18 includes measures regarding premature obsolescence:

> (…) "*9. In order to avoid the premature obsolescence of certain products, the Ministry for the Ecological Transition and the Demographic Challenge will carry out studies that analyze its useful life, and that serve as a basis for adopting measures aimed at avoiding said obsolescence and shall inform the Council of Ministers and the Cortes Generales within a period of two years from the entry into force of this law.*"

Regarding the access to information, consumers will be informed about the potential repairability of the devices that they are purchasing with the repairability index that has been

mandated in the new law. Article 18 concludes with paragraph 10, in which provisions for the repairability index are contained:

> (…) "*10. Those who sell electrical or electronic equipment in Spain will inform the consumer about the repairability of such products. For such purposes, regulations will regulate a repairability index for electrical equipment and electronics, as well as the obligations of information to the consumer about it.*"

3.4.4.4 Repairability Index

According to the Ministry of Consumption (MIC) (2021), the repairability index is a front label that shows, in a simple and visual way, to what extent it is possible or not to repair each device, allowing consumers to have this information when comparing different purchase options. It consists of a graphic label consisting of the words "repairability index" and a pictogram indicating the index score between 0 and 10 points.

In Spain, the MIC carried out a public consultation regarding the repairability index in 2021. The population that participated was informed about the purpose of the repairability index and the 5 criteria evaluated. The following table shows the criteria included:

Table 3-9 'Criteria Include in the Public Consultation'

	Criteria included in the public consultation
i.	"The documentation provided by the manufacturer to facilitate the repair, that is, the manufacturer's commitment to make available to authorized repair shops, free of charge, the technical documents, as well as the documents relating to advice on use and maintenance for consumers, for a reasonably long period from the marketing of the last unit."
ii.	"The ease of disassembling and accessing the part to be replaced"
iii.	"The availability of spare parts or specific tools (if necessary) and delivery times."
iv.	"The relationship between the price of replacement parts and the value of the original product."
v.	"Other specific criteria depending on the type of EEE"

Source: The official communication of the Public Consultation carried out by the Ministry of Commerce (2021).

The MIC is currently working on the Spanish Repairability Index. It has not yet been implemented or entered into force. Recently, in the Spanish *Law on Wastes and Contaminated Soils*, the repairability index was included. As can be observed, the French Repairability Index has had an influence on neighbor countries, and this can lead to implementation across the EU.

3.4.4.5 WEEE Management

Regarding the Spanish case, it is worth mentioning that Spanish waste collection and management policy has been increasing its efficiency and has had great evolution since its

beginnings. The European Court of Auditors (2021) have reported that according to the *European Commission's assessment of Member States' WEEE management policy* (2017) Spain, together with Austria, Bulgaria, Germany, Hungary, Ireland, Lithuania, Finland, France, and the UK, were included in Group A, which corresponds to high achievements in quantitative criteria. The aforementioned report is, from 2017, in December of 2021, Spain reported great results and achievements in documents such as *the second yearly report on trends of the recycling industry of WEEE and batteries in Spain* (title translated from Spanish) developed by Recyclia, which is one of the largest and most impactful PROs in Spain.

The European Commission (2021) reported in the study on *Quality standards for treatment of waste electrical and electronic equipment* in their review of Spain that several recyclers interviewed in a workshop reported that the ecodesign regulations for devices have not been put into practice and that this is a challenge for recycling and preparing for reuse. Because this was reported at the end of the chain by the recyclers, it can be understood that there is a lack of implementation in the design and production stage. More stringent regulations must be implemented and approved. Ferro and Ferro (2022) noted that there is no comprehensive set of requirements to ensure that all products marketed in the EU are increasingly sustainable.

De la Varga (2021) notes that, in the different Spanish sectoral laws, producers need to comply with the following obligations:

1. Design for low environmental impact
2. Design for multiple uses, durability and easy dismantling
3. Establish and manage deposit systems
4. Be held responsible for waste management
5. Use secondary raw materials
6. Provide information on the products placed on the market and those which become waste or create waste
7. Provide information about the economic aspects related to the Extended Producer Responsibility

Preparation for Reuse

In a nutshell, preparation for reuse is a policy and strategy that was first implemented in Spain, it consists on the collection of Electronics by means of the EPR schemes, and those that after an inspection and valorization process are found to be in good condition to be repaired if necessary and prepared to be reused.

One of the newest additions to Spanish law was the new objectives for preparation for reuse of WEEE, which was introduced firstly in the Royal Decree on Wastes from Electrical and Electronic Equipment 110/2015 with targets below 5% (2% for big electronics and 3% for the small ICT). The reformed *law for Wastes and Contaminated Soils* introduces more ambitious objectives in its article 26, which mandates that by 2025, 5% of the WEEE collected will be prepared for reuse, and the percentage will increase progressively until 2035, when at least 15% is expected to be prepared for reuse.

Reuse

The reuse and secondhand market of small electrical and electronic equipment in Spain has faced several barriers that hinders its scaling up. Some of them are related to the lack of habits regarding repair. In one study by Bovea et al. (2017), it was found that in Spain, only 12.4% of consumers have bought secondhand ICT.

Furthermore, Bovea et al. (2015), in their study regarding the reuse of small electrical and electronic equipment, found that there are several barriers during different stages of the secondhand process, such as those in the collection and classification stages, where for instance,

collectors usually do not take proper care of the devices and some that are still functioning are broken during this stage.

In regard to repair, the lack of spare parts was one of the major barriers in recent years (Bovea et al., 2015). Moreover, they found that during the reparation stage the barriers that hinder repairability are related to the lack of knowledge, and difficulty to access spare parts since there are many producers and many products on the market.

Furthermore, Bovea et al. (2015) found that consumers lack the habit of acquiring secondhand products. In addition, the study identified some barriers regarding the quality guarantee of the product, since it can be complicated to ensure the correct functioning of secondhand devices for more than 12 months, and that in some cases, no guarantee is given on devices that does not exceed a minimum economic value (Bovea et al., 2015). It is important to promote the design of small electrical and electronic equipment that takes into account the ease of repair, updating, as well as reuse, disassembly and/or recycling (Bovea et al., 2015).

Swedish Example of VAT Deductions

This study is focused in Spain, whoever it worth to observe the implementation of policies that have been effective in other countries of the EU. In Sweden, since 2016, IT services in the consumers' homes are positively affected by tax deduction for household work (RUT), and therefore repairing, among other services, is covered by the deduction on the labor cost to stimulate employment (Dalhammar et al., 2022). Repair is stimulated also by a differential VAT rate since 2017, when it was reduced from 25 % to 12%, IT included; attempts to reduce VAT to lower rates have been proposed (Dalhammar et al., 2022).

To conclude, what has been adopted in one country can potentially be replicated in another country since the repairability index can be implemented also in Sweden and Scandinavian countries. Spain is working on the implementation of the Repairability Index, as first introduced in France. This type of progress towards the transition to a circular economy in the electronics sector needs to be tracked by researchers and policymakers of other countries. There is a need to coordinate agreements to adopt the same schemes as other countries (Dalhammar et al., 2022).

As concluded in this literature review, in Spain there are no fiscal incentives to foster repair services of electronics, and in particular, of independent services for mobile phones. The new *Law for wastes and contaminated soil* consider two new fiscal measures to foster the Circular Economy, however they are designed for plastics and for waste landfilled or incinerated. A key policy that can be taken at the national level is subsidies to some repair activities, and/or tax deductions for repairs (Dalhammar, Milios, & Richter, 2021). Similarly, the possibility to implement repair vouchers such as those in Austria have to be explored by policymakers. The vouchers can be implemented and financed by means of introducing a repair fund in which companies pay a levy when they introduce products to the market (Dalhammar et al., 2022).

3.5 Conclusions from the Literature Review

This literature review demonstrates that Circular Economy options have to compete with the linear economy (Vence et al., 2022) and therefore it has to be attractive for both consumers and producers. As concluded by Garcia (2021), it can be expected that, due to the increase in the demand of sustainable products, the market will be naturally directed toward economic models with less environmental impact.

Under the Circular Economy, two important objectives are the production models and the reduction of raw materials used and GHG produced. For that reason, repair together with other activities such as refurbish and recycle has been identified as circular economy activities, which have to be fostered in order to achieve the objectives aforementioned.

Many new standards under the Ecodesign Directive focus on repairability, but consumers are more interested in durability (Dalhammar, Milios, & Richter, 2021). The repairability index is one achievement towards a circular economy as it has been implemented primarily in France since 2021 and is being replicated in other countries. However, the next step is the durability index, which has been announced already by France and is expected to enter into force by 2024.

There is a need to review the legal framework of certain products to create a stringent regulation to certain products or materials (Maitre-Ekern & Dalhammar, 2019). For instance, low quality products can be banned progressively in the European Union or affected by an environmental tax. It was found by Ertz et al. (2019) that one of the most important reasons that influences the decision to repair was the quality and cost of the electronic device.

Likewise, legislation and regulation can, in themselves, send signals to consumers and producers which thereby contribute to changing norms (Dalhammar et al., 2022). More repairable products and easy access to repair will lead to a behavior of consumers towards more repair.

In the words of PACE (2021), "we should take proactive action to optimize the impact of a circular transition, including leveraging win-wins for maximum benefits, mitigating trade-offs and risks, and investigating the yet unknown." All the stakeholders involved have to cooperate to align their efforts towards a sustainable market of electronics. More stringent regulation needs to be adopted without hesitation (De la Varga, 2022) to meet the necessary, but ambitious targets.

4 Findings

4.1 Final Causes

4.1.1 The Circular Economy

The EU is moving to a Circular Economy to meet its environmental objectives and for this reason, governments are pushing to change the current situation of products placed on the market. This can contribute to achieving the objectives of the Green Deal. Together with all the changes and proposals, there are many sectors that can benefit and need to be prepared because we are facing a technological era in which more and more devices are being used. This industry already plays a very important role in the economy. The advocates of CE are creating the legal framework to allow the change to lengthen product lifetimes and encourage more repairs (Dalhammar et al., 2021). Circular Economy activities (repair, reuse, refurbish, remanufacture, repurpose, and recycle) will be fostered and this will contribute to the creation of new jobs and new opportunities. In the CE repair is one of the favorite activities since it is a way to expand the lifespan of electronics. The regulation of products is central to this process (Maitre-Ekern & Dalhammar, 2019).

This shift is not easy and requires the cooperation of many sectors and stakeholders to be able to develop. For instance, in the case of mobile phones, governments must pass regulations, standards, requirements, and incentives. OEMs have to design their products with material usage and more repairability and upgradability considered since the initial design phases. Society and consumers have to prefer repair rather than disposal or replacement.

In the CE repair has been one of the favorite activities since it is a way to expand the lifespan of electronics.

4.1.2 Raw Materials

Mobile phones contain a diverse range of raw materials, and while each device contains just small quantities, considering the total number of mobile phones sold every year, that small amount contained in each device contributes to a large mining industry. The raw materials contained are raising international concern (European Commission, 2020). Among the strategic materials, electronics contain lithium, which has become the preferred technology for LIBs. The use of strategic materials can be reduced considerably by 2030 (European Commission 2021; IIIEE, 2021), if ecodesign requirements are applied. Under the new regulations on electronics, it is expected that one of the new requirements placed on OEMs will be to indicate the exact number of raw materials contained. The Circular Economy approach aims to reduce the amount of raw materials used by "slowing" and "closing" loops (IIIEE, 2021; Ertz et al., 2019).

4.1.3 Greenhouse Gas Reductions

The extraction and processing of raw materials contribute to 50% of global GHG emissions (European Commission, 2022). Circular Economy measures seek to reduce the use of primary raw materials by keeping the product and extending its value on the market in addition to the proposals to foster the use of secondary materials in production. Both actions have the potential to contribute to the reduction in the amount of raw materials used and consequently in reducing the emissions of greenhouse gasses.

The WARM Model (2021) Circular Economy activities such as repair must be preferred over recycling. The repairability of electronics, and in particular of phones, can help effectively in

reducing GHG emissions from this industry since less production will be required if the lifespan of the product is extended.

4.2 Scope Identification

4.2.1 Mobile Phones

Mobile phones are one of the most important products that are currently used due to all the functions that users can get from a single device. Sales started increasing rapidly in 2009 reaching the high number of units currently sold (Valero, Calvo, & Valero, 2021). Several studies have found that this devices are currently used by most of the inhabitants of some countries, for instance, in Spain, only 1.5% of the respondents don't own a phone (Bovea et al., 2017), other studies found that there are more phones than inhabitants in Spain (Dorado, 2018; Back Market study, as cited by Beltran Puentes). Due to the importance of these devices and their intensive use, studies and research have shown that this category of electronics is the one that is more repaired (Ertz et al., 2019), and that special attention has to be put to extend the lifespan of this type of device as much as possible. Among the causes to repair, battery issues were found to be the most common problem (IIIEE & EEB. 2021). The durability of phones is a new aspect that is being pushed by the R2R movement.

Repair of mobile phones has to be easier and faster, otherwise, consumers will keep opting for replacement. Extending the use phase of these devices is crucial because every year millions of devices are produced, and, as it has been commented, the biggest environmental impact is caused during the production phase. As research has shown, the number of mobile phones is surpassing the number of inhabitants in some regions. As it was perceived by the researcher in the cities visited to gather and collect data, repair for mobile phones is the most common type of repair shop for electronics.

Finally, as it is commented in the Repairability & R2R Movement, and in the Repairability Index sections of this thesis, mobile phones are one of the most important categories considered under this movement. These initiatives, being pushed across Europe, will lead to more repairs in the future if the policies are successful.

4.2.2 Small ICT Stored at Home

An inevitable consequence of the high functionality that ICT devices, and especially mobile phones, have is the so-called "treasure effect", which occurs when people store their device at home even after its useful life due to the information and data contained in the memory (European Recycling Platform Spain, 2020). As PROs (SCRAPs in Spanish) have reported, the small ICT devices are still hindered from the collection (European Recycling Platform Spain, 2020; Recyclia, 2021). At the end of a mobile phone's lifecycle, when reuse and repair is not possible, it should be collected to be refurbished or recycled. The older a phone gets, the more difficult it will be to repair it because of the limitations of spare parts, mostly because every year there are many new devices.

There is a clear need to establish collaborative policies between the different stakeholders involved in this issue. Some companies have implemented take-back programs, which are mostly used when consumers have already purchased a new device. It is important to note that small ICT is not the only category that tends to be stored at home. In the future, the transfer of data must be more accessible, otherwise, history will repeat itself and, once again, current devices will be stored. For future devices and models, data storage and erasure have to be considered to avoid the waste of raw materials.

4.3 New Policies and Changes that Influence the Repair Sector

4.3.1 Repairability and the Right to Repair (R2R) Movement

In the European Union, legal disposition regarding the circular economy activities related to mobile phones such as repair can be found in diverse instruments. However, it is necessary to keep the regulations on repair diversified since there are many aspects involved, such as environmental aspects (Waste Framework), product design aspects (Ecodesign Directive), consumer aspects (Sales of Goods Directive), and governmental aspects (Green Public Procurement). Many of the legal dimensions of repairability policy are considered in the different legislations and directives. A combination of policies can influence the promotion of repair (Dalhammar et al., 2019). There are different directives, policies, and laws in the European Union that promote repair, which is important because one single policy or regulation will not be enough, and a well-designed policy mix is paramount.

Repair activities performed on mobile phones have a large potential to reduce the use of raw materials and GHG emissions with the implementation of strategies aimed to "slow" and "close" the loops (IIIEE, 2021; Ertz et al., 2019). However, these CE strategies and improved access to repair are contrary to the interests of most OEMs, who have limited the access to repair by different means, such as requiring the use of special tools to repair, limiting the availability of spare parts, and creating software and design incompatibilities with older models (Maitre-Ekern & Dalhammar, 2016). The Right to Repair movement has pushed new legal initiatives to fight against those barriers created by OEMs, and some of these proposals have been passed in the EU and some others are being discussed and reviewed.

One of the most important factors that contribute to a consumer's decision whether to repair or not is the price of the service since, in some cases, the repair is more expensive than a new device (Sonego et al., 2022). Consumers are not willing to pay for a repair that costs more than 30% of the total price of a new device (Ertz et al., 2019). Usually, the higher the cost of a product, the higher the possibility of it being repaired (Dalhammar, Milios, & Richter, 2021). Therefore, low cost of new devices tends to discourage repair (Milios, 2021), and so if there is no marginal difference between repair and replacing with a new one, consumers will keep preferring to replace (Sonego et al., 2022). The difference in cost between spare parts and new devices just convinces consumers to purchase new devices (Maitre-Ekern & Dalhammar, 2016).

Battery change is one of the most common causes to repair (Bovea et al., 2017, IIIEE & EEB, 2021), and this process can be easily done by repairers. The study developed by the IIIEE & EEB (2021) identifies important barriers that have to be eliminated to foster repair, not only of batteries, but also of mobile phones and other electronics.

New formulations and proposals to legal inputs are being discussed currently, such as the ones considered in the *Ecodesign preparatory study* (2021), in which one can easily observe that some of the issues derived from barriers created by OEMs are addressed. For that reason, the study includes provisions regarding spare parts (including batteries, display, and chargers) and the delivery time of the parts.

Regarding the qualitative data gathered by means of the interviews, interesting details about the repairability of phones emerged. It was noted that all the participants did not know about the Right to Repair movement and are not aware of the direction that the electronics sector is taking towards repair. Only one participant (Number 6) was even somewhat aware about the movement, but the rest were unfamiliar with it and its objectives.

4.3.2 Repairability Index

This labeling strategy has already been implemented in France since 2021, and has recently been announced by Spain that a similar label will be adopted as well. This label consists of mandatory information about the device's potential to be repaired. Mobile phones are one of the product types covered by this label and 5 aspects are considered: (1) documentation, (2) disassembly, (3) availability of spare parts, (4) price of spare parts, and (5) product specific aspects.

Labels, such as for energy, have achieved positive results and, thus, it can be expected that the repairability index can influence the purchases of consumers just as the energy label did, because, for instance, 79% of consumers in the EU took these labels into consideration when buying electronics (European Commission, 2021). These types of labels can cause a positive change in consumers when purchasing new devices and, as a consequence, negatively affect producers of those devices that have a low repairability rate.

4.3.3 Ecodesign

The design of devices, and specifically of smartphones, is very important for its repairability. The EU has adopted and implemented specific regulation regarding product design. The right implementation of the requirements has great potential to benefit the producers and the consumers.

The ecodesign Directive has influenced the production of electronics and is expected to include more categories in the future. In addition, this directive is being reviewed by the European Parliament with the purpose of enhancing its application and results and of reducing the barriers to repair created by OEMs.

Ecodesign has resulted in several benefits to producers and consumers (European Commission, 2022). The European Commission (2022) recently announced that sustainable products will be the norm. This directive takes a preventative approach (Beltran Puentes, 2021) and contains legal provisions aimed at fostering the repair and repairability of electronics. It has been estimated by the European Commission (2021) that this policy, by 2030, will reduce the number of phones placed in the market by 26%.

The Ecodesign Directive and some of its requirements benefit the repairers sectors (the official repairers and the independent) since one of its main objectives is lengthening the use phase.

New regulations on Ecodesign are critical because, in the new requirements, devices will be designed to be repaired, which will be beneficial for consumers and repairers.

4.3.4 Fiscal Incentives for the Circular Economy

Governments need to implement fiscal schemes that allow for and foster Circular Economy activities such as repair and recycling, among many others, by means of levies or tax deductions. A positive example of the implementation of financial incentives is the VAT deduction in Sweden (Milios, 2021). Tax schemes and systems should favor all those activities related to the CE, such as repair services. Other types of fiscal incentives are found in the EPR schemes, which encourage the OEMs to design more repairable, reusable, or recyclable products.

Dalhammar has suggested the implementation of a bonus/malus fee, in which the producers of those devices with better environmental features will pay less, and conversely, those with worse features will pay more. Additional fiscal incentives or taxes can be imposed on raw materials use (Milios, 2021) where the secondary materials are considered in order to preserve the market value.

4.3.5 The Fight Against Programmed Obsolescence

Obsolescence causes the premature replacement of mobile phones and multiple causes for this have been identified by researchers. Obsolescence is one of the major barriers to repair and challenges for the durability of electronics. Progress against obsolescence has been achieved in some European countries, such as France and Italy. In other countries, such as Spain, authorities are studying the situation so as to implement actions against it.

Repair activities are effective against some types of obsolescence. For this reason, it is important to foster repair in the sectors of both the official and independent repairers. Limited access to spare parts and the cost of repair are two of the main obstacles for repairers.

The Right to Repair movement is fighting against obsolescence by means of different policies that have already been passed in congresses in the EU and US. These policies benefit the independent repair sector directly and indirectly because more services will be required. A well planned and coordinated policy mix is the necessary solution against some types of obsolescence, and for that reason, it can be observed that some measures are starting to be implemented across Europe.

4.3.6 Extended Producer Responsibility (EPR) as an Instrument of Environmental Law

The repair of electronics is being pushed with many policy instruments. EPR can play an important role to incentivize producers toward better Ecodesign, which is particularly important as one of the new trends in Ecodesign is repairability. Thus, EPR incentives can benefit repairs in the long term if the right policies are created and applied such as financial incentives or reductions in EPR fees.

EPR was initially established to improve waste management and collection, however, now needs have changed because the systems are well developed in the EU, and so the prevention of waste has become a priority. Finally, the repair sector benefits directly from ecodesign policies which promote repairability and durability.

4.3.7 Pre-market Producer Responsibility (PPR)

PPR is a relatively new concept that is starting to evolve as the requirements for electronics are becoming more stringent. The precautionary principle is applied in these policy measures. This new concept can be understood as an evolution of EPR. Among the proposals of this principle, two important aspects related to repair are considered: (1) provision of information about the repairability and (2) availability of spare parts. Ultimately, producers are responsible for extending the lifespan of a product as much as possible before it turns into waste, and when it reaches its end-of-life, recovering it through an efficient take-back system.

Of course, this principle will require the cooperation of different stakeholder groups, such as producers and legislators. Still, the proper implementation of this principle would have a positive impact since those products that do not comply with the requirements would not ever be placed on the market.

Once again, it was identified through the literature review of this topic that this principle has the potential to benefit the repair sector, however these benefits will only be realized in the long-term. In addition, PPR will contribute to reducing the amount of waste as currently, we are dealing with the historical waste from EEE that was placed in the market without any consideration for repairability.

4.4 Different Points to Consider in Different Stakeholder Groups

4.4.1 Consumers

4.4.1.1 Consumer Behavior Toward Repair

It is important for policymakers to analyze and understand the behavior of their society in order to change the behavior of consumers. People prefer to throw away rather than keep their devices for longer periods. If products are better designed, for example through ecodesign, with longer durability, and with easy access to repair, better results can be achieved.

To avoid unnecessary disposal of electronic devices, it is important to create a well-designed policy mix that considers different aspects, such as repairability and access to repair. Information alone can be useful, as if consumers are aware about the possibility of repair, how easy or complicated it is, and its potential cost, their behavior towards repair can be influenced.

Researchers have concluded that the regulation of products is critical in influencing the behavior of consumers towards repair (Maitre-Ekern & Dalhammar, 2019; Dalhammar, 2022). The amount of electronic devices, and specifically, mobile phones that are being repaired every year has to increase if we are to meet the objectives of these new policy attempts to foster repair.

4.4.2 Repairers

New regulations will seek to provide all the information that repairers need to know to repair all the devices. Both sectors of repair, the independent and the official, can benefit from these new legislative changes. When a device is broken, consumers should, preferably, have it repaired by either an authorized service provider or an independent repairer. The independent repair sector can be benefited if a more open access to repair is allowed.

In addition, lack of information about complex components contributes to the so-called "repair monopoly" that OEMs have on the repair market. The new inputs proposed in the Ecodesign Preparatory Study (2021), are considering that the producers shall provide more open access to information to those that meet the requirements. The certification of repairers can help them to increase their repair rates since the consumers can be confident about the quality of the repair (Ertz et al., 2019). Repair services in general can be more accessible in both sectors of repair if this monopoly is eliminated.

The repair sector is one of the sectors that will benefit from increased repairability of the design of phones, as well as consumers and access to spare parts at a reasonable cost. This is partly because improving the repairability of phones will lead to the increase in the employment in the industry.

Different measures have to be implemented to support the independent repair sector, such as tax schemes created to favor circular economy activities to foster its competitiveness (Milios, 2021), and local municipalities will play an important role in the implementation of these policies.

Repair Vouchers

Good practices that are intended to foster repair by means of supporting the independent repairers are mentioned in the literature review, such as the repair voucher implemented in Austria (Almen et al., 2021). The repair voucher is a good instrument that can influence the behavior of citizens towards repair since they can be aware about the potential that their devices have to be repaired.

4.4.2.1 Information Provided to Repairers

Under the new ecodesign requirements and the Right to Repair movement, it has been proposed that the access to information about the repair has to be easier and faster in order to improve access to repair. In addition, it has been also proposed to expand access to information for consumers as well. Researchers have found that, despite the fact that it is easier for consumers to get the information to repair their devices personally, the repairs carried out by repairers have higher rates of success (Ertz et al., 2019).

4.4.2.2 Reuse and the Secondhand Market

To increase the purchase of secondhand products, there are many changes that have to be implemented in the repair sector. For one, the confidence of the consumers on this type of products has to be increased. Repaired products and secondhand products often offer a legal warranty to consumers; however, despite this, the preference for this type of products is low. Repair activities benefit directly from the reuse of secondhand phones, since in many cases, the independent repairers sell repaired devices in their local stores.

In the waste hierarchy established in the Directive 2008/98/CE, Article 4, waste prevention and preparation for reuse are among the preferred options. As it has been previously mentioned, in Spain the preparation for reuse targets is important to achieving higher reparability. Some of the electronics collected to be prepared for reuse are obtained by the EPR schemes. After a process of valorization and analysis, the devices are repaired when it is necessary and then displayed at secondhand stores.

In France there are proposals to certificate repairers in order to repair the electronics collected under the EPR Schemes (Dalhammar, 2022).

In addition, the Ecodesign Directive and similar, new requirements are intended to extend the life cycle of electronics as much as possible, and for that reason, repairability is considered as one in early stages of the production phases such as the design to allow secondhand and reuse. Together with design and the availability of spare parts for longer periods, for instance the one mandated in the *General Law on Wastes and Contaminated Soil*s, are policies intended to foster repair and secondhand repair. Additionally, some proposals under PPR argue for the obligation to establish a secondhand and reuse section in electronics stores (Maitre-Ekern, 2021).

There are several barriers to secondhand use that have been identified in the literature:

1. Buying new is preferred most of the time (Maitre-Ekern & Dalhammar, 2019)
2. Personal data stored in the ICT (Bovea et al., 2017; ERP, 2020)
3. Psychological obsolescence (European Environmental Agency, 2021)
4. High cost of labor to repair (Dalhammar et al., 2021)
5. Legal warranty and duration (Dalhammar et al., 2021)
6. Lack of incentives for secondhand and reuse (Milios, 2021)
7. The quality of the products influences their popularity on the market (Dalhammar, Milios, & Richter, 2021).
8. New generations of products compete with older generations (Gulserliler, Atasu, & Van Wassenhove, 2022)

4.4.3 Producers

4.4.3.1 Intellectual Property and New Business Models

Producers have resisted change and have created various barriers to protect their brands and limit access to information and repair. Intellectual property (Vence et al., 2021) and limiting

access to spare parts (Dalhammar et al., 2021) are some of the challenges for repair. How business models are established must be analyzed and modified in a way that is beneficial for companies, for only then will they reduce the barriers to repairs that they have imposed. Ultimately, new and sustainable business models must be created. Furthermore, it is necessary to create the incentives and frameworks needed to create wide agreements across the electronics industry (PACE, 2021).

Barriers established by OEMs have hindered cheap and easy access to repair. The Right to Repair movement is pushing OEMs to allow for more open access to repair of their products. Easing repair by professionals is similarly important as a further step toward better repairability by consumers (European Commission, 2021). The independent repairers sector has to be included in this shift since some of these technicians do have the necessary qualifications to perform repairs.

Cloning is likely if information about the design is provided publicly to consumers in general and to the repair sector; however, this can be avoided by deploying new business models such as servitization (Gulserliler, Atasu, & Van Wassenhove, 2022).

The European Parliament has announced plans to foster a shift in the economy and achieve a circular model in the new proposals to make sustainable products the norm (European Commission, 2022). Potentially, in the future, repair will be much more necessary if new business models are established such as servitization and for that reason, it is important to reach agreements between the different stakeholders in which they can all be involved because each one plays a unique role in circularity.

The CE will create new job opportunities in which repair will be needed. In addition to independent repairers, this transformation will benefit many stakeholders, such as producers and consumers. It is necessary to explore all possible solutions to establish a well-planned system.

The European Commission (2022), in their document, can conclude this section succinctly, saying:

> "There is a clear need to identify bottlenecks, identify effective means to boost the uptake of circular business models, ensure their profitability, make them increasingly attractive to consumers, exchange the best practices, and provide tailored advice for new and existing businesses to switch to circular business models."

4.4.4 Main Spanish Legislation and Policy Instruments Toward Repair

4.4.4.1 General Law for the Defense of Consumers

The provisions regarding spare parts for a period of 10 years after the last product is manufactured are considered in Article 127 bis and entered into force in March 2021. In addition, in the same article, an obligation is established that producers must provide technical service within that 10-year timespan. The objective of this law is to foster repair and access to it, which will result in extending the lifespan of products, and in this specific case, mobile phones.

In addition, the legal warranty was extended from 2 to 3 years in the Article 120 of said law. Extended warranty periods can result in an incentive to repair (Maitre-Ekern & Dalhammar, 2016). This new measure addresses some of the barriers that hinder repair since the accessibility of spare parts has been one limitation to repair.

4.4.4.2 The Circular Economy

Spain is following the European Union Circular Economy and its principles, as evidenced in *The Circular Economy Spanish Strategy* (2021) and the *Circular Economy Action Plans 2021-2023* (2021), a set of objectives that are planned for a more sustainable country. Two of the main goals in *the Circular Economy Spanish Strategy* (2021) are the reduction of waste and greenhouse gasses. In *the Action Plan for the Circular Economy 2021-2023* (2021), among the spheres of action are production, consumption, waste management, and use of secondary raw materials. Moreover, there are considerations for electronics and specifically for mobile phones, regarding its regulation, the extension of its lifespan, and its collection and management as waste.

4.4.4.3 Spanish Law on Wastes and Contaminated Soils

This law entered into force in April 2022 and includes most of the new policy changes that can influence the electronic sector towards more repair with the purpose of reducing the pollution caused by WEEE. This law provides the foundation for other legislative measures that have entered into force recently to prevent the generation of waste through circular business models, ecodesign, management of raw materials, and other policies which promote repair, and access to spare parts.

In addition, in said law, there is legal provision that sets the basis for future studies to regulate programmed obsolescence within the next two years. Spanish authorities carried out a public consultation regarding the repairability index and with this new legal initiative, the obligation to implement it is included for the first time.

Preparation for reuse is included in the changes that can influence repair, due to the fact that the targets were increased to 15% of the total weight of devices collected being reused by 2035. Together with considering the preparation for reuse, policymakers must understand the attitudes of consumers toward secondhand products since the rates of consumers that have bought this type of device have historically been low, as discovered by Bovea et al. (2017).

Spain has passed legislation that seeks to foster the repair of electronics to achieve its Circular Economy objectives, including recently announcing the implementation of the Repairability Index, which will be a positive measure to promote repair. For all such policies, independent repairers have to be considered. Regarding the Repairability Index, it was found that the independent repairers that were interviewed were not familiar with it or with the direction that the electronic sector is taking toward repair. In the group of independent repairers interviewed, no one knew about the Repairability Index and this policy.

The uptake of secondhand products in Spain must be increased and the confidence of the consumers on this type of electronics has to be enhanced. Certifications on secondhand products and their repair can be a very effective way to guarantee quality. New models should be designed that consider the repairability and second use of the product. This aligns with the "Pre-market Producer Responsibility" described by Maitre-Ekern (2021) and its principles. This can also result in major benefits for independent repairers and the sector as a whole.

As can be observed in the example of Sweden, it is important not only to create legal frameworks, but also to think of incentives and policies to foster repair, and secondhand markets. Repair activities are stimulated by differentiating VAT rates.

4.5 Findings and Analysis of the Qualitative Data Obtained from Interviews

This section analyzes the context of the independent repairers sector in Spain. The findings of the literature review were analyzed logically and allowed the author to create a set of codes about different topics that were adapted to the questions of the interviews with independent repairers in Spain. The codes used for the analysis with NVivo are provided in the Appendix C.

Section 1: The interview protocol

The protocol was made out of the findings of the literature review, the explanation of the logic behind each question is included in this chapter. Two sets of 15 questions, named as guide A & B, where prepared with the specific purpose of delving deeper in specific topics.

Thus, the guide A was intended to delve deeper into: ecodesign, spare parts, access to information, support from the government and producers, repairability index and environmental awareness. Whereas the guide B was intended to delve deeper in the following: Repair associations, spare parts, access to information, certifications, alternatives, repairability index, legal warranty and environmental awareness. As can be notices from the titles of the topics, some of them are repeated in in both guides, however this was planned on purpose to delve deeper in those aspects. Each guide has a set of 3 questions that worked as introduction in the interviews.

To begin with, **guide A** is explained in the following paragraphs:

Introduction

A1:Can you explain what type of repair activities are performed in this repair shop?
This question is intended to identify whether if there is a major presence of repair shops that perform fast repairs or not. It was identified that in the literature review (chapter 3.2.1) that in the mobile phones the most common causes to repair were related to those called fast repairs, which are intended to repair/change batteries, screens.
In addition, as mentioned in section 3.4.2 of the thesis, there is currently an open and close access to repair which influence which type of devices can be repaired by the independents.

A2: Is this your main occupation or do you have other?
This question was intended to identify the specific aspects about the population studied with the purpose of understanding the social and economic context as well as learning about the background of the interviewees.

A3: Are you aware of the new policies and regulations regarding the repair of phones?
As it is constantly mentioned in this thesis, there is new regulation and proposals by the European Commission on EEE that influence the mobile phone sector. Basically, it wasn't expected to obtain relevant answers from that topic since not all the people track and follow the process of laws and regulations. However, there was specific interest in learning about the perception of the independent repairers on all the regulation and new proposals recently approved in the Spanish legislation as it is explained in the section 3.4.4. Moreover, as it was communicated by the Spanish government, there were several periods of public consultation regarding the amendments on EEE and WEEE.

Ecodesign.

A4: In the last 2 years have you perceived any positive or negative change that influence the easiness to repair devices?

In the section 3.3.3 of literature review was found that the EU has been pushing ecodesign and this is not a recent requirement. Moreover, by means of the implementation of ecodesign in the actual practice, many benefits can be achieved. Furthermore, preparatory studies on ecodesign have been carried out to identify which are the prioritary actions that has to be taken and in which devices has to be implemented first due to its priority need to be regulated. Among the findings, the table 3-3 shows the Ecodesign strategies, in which "design for maintenance and repair" play a fundamental role. That is the perspective of researchers and producers, yes, however at the end of the chain, there is the opinion of repairers and recyclers. Thus, to identify and to track if there is real implementation on the smartphones sector this question was included. Finally, as its mentioned in the thesis, Spanish dismantlers and recyclers of WEEE, mentioned in a workshop carried out by the European Commission (2021) that there is a lack of implementation on ecodesign.

A5: Is the time to repair being reduced? (Less labor hours to repair)

The logical reasoning behind this question was to identify two fundamental aspects that were found in the literature review regarding the implementation of ecodesign requirements that were supposed to made devices easier to repair by professionals. Secondly, by means of this question was intended to learn and understand about the current situation. As it is commented in the section 3.3.3. of this thesis the ecodesign directive was implemented in 2009.

As it was found in the literature review, producers and companies are making the devices more complex and for that reason it's harder to repair them or it takes more labor hours for the repairers. In some cases, this is made on purpose so that only the official repairers can fix a device because they are the only ones provided with the specific tools or spare parts. In some other cases is not necessarily on purpose but this is a secondary effect of having more complex devices with new technologies.

A6: In the case that repair is faster and easier, would you reduce the price of the repair to consumers?

As it is mentioned in section 3.3.3. of this thesis, , referencing the European Commission (2022) if product repair become more mainstream, consumers can save money on their purchase. Moreover, in the same section of this thesis it is mentioned that the cost of repair is a decisive factor for consumers. Previous research has found that consumers are willing to pay approximately between 19% and 30% for the repair compared to the replacement price of household appliances (Adler & Hlavacek, 1976; European Commission, 2018; McCollough, 2007, as cited by Ertz et. al, 2019).

Spare Parts.

A7: Is it easy to access to spare parts? Is there any specific brand that is easier or complicated to access to spare parts and tools?

The logic behind this question is to identify if the access to spare parts is a barrier for Spanish independent repairers. In previous research has been found that access to spare parts is a barrier to repair in the case of batteries., as well as the impossibility to access to specialized tools.

A8: What are the most important barriers when you want to repair a device.

The understanding of the current barriers faced by independent repairers is fundamental. As it was found in the literature review in section 3.4.3.1 some of the barriers are related to intellectual property. In addition, as is explained in question A7, access to spare parts is another barrier. As

well as those barriers found in the literature review, this question is intended to find emerging data related to other type of barriers.

A9: How did you obtain the information and manuals to repair?
Once again, in section 3.4.3.1 of the literature review was found that intellectual property has hindered repair for independent repairers. Moreover, section 3.4.2.1 of the literature review points out about the easy access to information to repairers. Furthermore, in section 3.3.7 of the literature review is commented about the PPR (pre market producer responsibility), in which one of the fundamental points of it is the provision by producers of the information related to repairability of devices. The right to repair movement commented in the section 3.3.2 advocates for the easy and open access to information.

Thus, this question aims to understand how does the independent repairers access to information since information and manuals are fundamental to carry out a successful repair. In the Spanish context, there are new provisions regarding the prevention of waste in which it is contemplated the easy access to information without prejudice to property rights.

On theory the above has been stablished, however, this question has the purpose of identifying what is the reality in practice.

A10: Have you perceived any difference on the accessibility to information?
Basically, this is a follow up question to identify if there has been any process of improvement from theory to practice.

Support to repairers from the government and producers.

A11: Is there any support from the government? Is there any fiscal incentives or tax deduction? A12: When opening the repair shop, did you receive any support? A13: Is there any company that support access to repair by any means?
This block of questions is intended to identify if currently there is any type of support to independent repairers in Spain. In section 3.4.4 of the literature review it is commented about policy instruments and laws intended to foster repair however it wasn't found any relevant support to repairers. Section 3.3.4 of the literature review comments about fiscal incentives, that can be helpful for circular economy activities such as repair. Moreover, in the same section it is commented about the Swedish example regarding VAT deductions, or the French example, however in Spain it wasn't found any type of support.

Repairability Index

A14: Have you heard about the repairability Index? How do you expect this to influence your business?

3.3.1 and 3.4.4.4 of the literature review discuss about the repairability index and its potential to contribute towards more repair of devices. Thus, it can't be discussed about repairability and repair without considering repairers. This question is intended to identify their opinion and perspective regarding the aforementioned labelling policy, which is in process to be implemented in Spain

A15: What do you think about the raw materials contained in the phones?
Basically, this question has the finality to identify and rate the level of environmental awareness of the independent repairers since the author of this thesis considers that if the level of

environmental awareness is high the repairers would be more involved and interested to collaborate.

Guide B
Introduction

1B Can you explain how did you acquired the knowledge and expertise to repair phones?
2B How long have you been performing repairs?
This block question pursues two different objectives, the first is to understand the background of independent repairers since this sector of repairers is less competitive than the so-called official repairers, the difference is not necessarily because of lack of preparation or technical expertise, but lack of support since the former category is supported by big companies. The second is to learn about the level of expertise of the independent repairers.
Section 3.4.2 of the literature review comment about "open and close' access to repair, thus, this question was important to learn and understand how does the repairers get the technical skill in order to be able to provide services under the open scheme.

Bhava you heard about the Right to Repair movement? If yes, what?
Similar logic to the question A1

Repair associations

BE: Is there any repair association? If yes, what are the main benefits of being member? If not, would you be interested in forming part?
As it was identified in the section 3.4.2, there are associations, such as in the case of Austria, there are repair networks, in which to form part of it, there are certain requirements that once are meet, the repairers have access to information, spare parts and certain benefits. This type of associations helps to make the repairers sector more competitive.

Furthermore, regarding the Spanish context, in the literature review it wasn't found anything related to this type of associations, For that reason this question aimed to explore and learn about the Spanish situation.

Spare Parts

B5: In the situation that you have better and cheaper access to spare parts, would you reduce the cost of your services to repair?
Same logic as question A6.

B6: Do you obtain spare parts directly from the producers or is there a thirds party that provides the parts?
Section 3.4.2 of the literature review comments about the open and close access to repair, hence, in the case of the independent repairers, they don't get the spare parts directly from any producer. Moreover, in 2021 in the Spanish Action Plan for the Circular Economy, there are actions intended to give loans to support member of the industry that support and implement policies on access to information of the product to ease its reparations. This question is intended to identify if this has brought from theory to practice, for instance, by means of providing independent repairers with spare parts. Thus, this policy together with certification can play an important role towards more repair of mobile phones in Spain.

Information

B7: Would you be interested in paying an annual fee for accessing to information?
As it was found in the literature review, access to information is one of the barriers that independent repairers have to face. Moreover, it was found that some producers offer information to repairers if they meet certain requirements. Having easy access to information can be helpful to reduce de barriers for repairers. One of the benefits that Austrian repairers obtain by means of the repair associations is access to information. Thus, this question was intended to learn about the Spanish situation and the willingness to pay for that.

B8: Is there any company that facilitate access to official information?
Similar logic to question B6

Certification:
B9: Do you have any certification to repair? If yes, how did you obtained it?
B10: If not, would you be interested in getting certified?
This block of questions is intended to learn about the background of the repairers and their willingness to be certified. In the section 3.4.2 of the literature review, it was found that certifications for repairs can inform the clients about the quality of the repairs.

Moreover, in the same section of the literature review, it is commented about the EPR schemes in France in which repairers can be certified to be able to repair secondhand devices and this way contributing to meet the objectives of the preparation for reuse set by Spanish government.

Thus, the certification of Spanish repairers can have a double effect, on the one hand contribute to enhance the confidence of consumers on repair. On the other, can foster the use of second-hand devices.

In addition, those repairers with certification can access to spare parts as it was found in desk research, some producers allow independent repairers to access to spare parts and information if they hold a certification and meet a series of criteria established by the OEMs.

In addition, as it was found in the literature review in the section named Preparation for Reuse of the number 3.4.4.5 of the literature review, the collaboration of independent repairers can be very helpful to meet the objectives set in Spain

Alternatives:

B11: Would you be interested in accepting repair vouchers? (Explanation about the concept is given to the interviewee)
This question was intended to learn about the opinion of the repairers towards the implementation of vouchers. Section 3.4.2 of the literature review mentions about the successful example of the repair vouchers in Austria in which each household receive up to 100 euros once a year to repair devices.

B12: Would you receive an old phone in exchange for services or reduction in costs of the repair?
This question was planned to know if the repairers would be willing to receive and old phone in exchange for reduction in the cost of the services, since, as it was mentioned in section 3.2.2 of the literature review, there is a problem with the Small ICT stored at the households.

Repairability Index:

B13: Did someone consult you about the repairability index? In your opinion what are the advantages of this informative labeling?
Similar logic to question A14 and 3B

Warranty.

B14: Which do you think that is the benefits of extending the legal warranty of products from 2 to 3 years?
This question was intended to identify if the repairers offer a warranty on the devices that they repair in case that there is any failure.

Environmental Knowledge.

B15: What do you know the relationship between mobile phones and the environment?
Same logic as question A15

Section 2: The interviews

Access to Information About Repair
Repairers interviewed mentioned that it is easy to obtain the necessary information and skillset to repair the devices (Respondents 1 and 12). In addition, it was mentioned that there are many different sources to get information on repair, such as YouTube (Respondents 11, 12, 1, 5, and 6), Google (Respondents 1 and 3), repair groups, and chats online and websites (Respondent 7). Additionally, some repairers mentioned that they do not need external sources of information because they have learned through experience (Respondents 2, 7, and 13).

Alternative Methods of Payment for Repair Services
The possibility to implement alternative methods of payment was very briefly explored in order to set a basis to suggest further research on this topic. The question concerned if they were willing to accept an electronic device, and specifically, an old mobile phone, in exchange for a deduction on the price of the repair as a possible solution to the problem collection of small ICT. This question was justified by the research mentioned in the literature review (Bovea et al., 2017; ERP, 2020), in which the small ICT equipment tends to remain stored at households. However, none of the respondents were interested in this idea.

Barriers to Repair, as Mentioned by the Repairers
One repairer (Respondent 12) mentioned that access to tools is not a problem, however more tools are required these days than in the past (Respondent 3). Producers do not sell original spare parts and have established closed access to repair (Respondent 12) and not all the components of phones can be completely repaired such as those that are small or those that are glued (Respondent 6). The price can be a further barrier since some of the spare parts are expensive (Respondent 3).

Regarding the intellectual property, it was mentioned that companies do not sell original parts to independent repairers since they only sell to the so called official and they do not allow other

technicians who work on their side (Respondents 12 and 13). One mentioned about the prohibition to sell original products or advertise any logo of the brands in their repair shops, commenting that he can get in trouble and all the commodities with the logo can be taken away, which represents a loss for him. (respondent 1). For that reason, it was noticed that independent repair shops in Spain sell the so called "Chinese versions" or copies of the original.

An additional barrier that emerged during the interviews is that some of the independent repairers have degrees and certifications on repair, however, due to the fact that those certifications were not granted in Spain or neither the European union those degrees are not valid or recognized. Which turn out to be an indirect barrier caused by migratory issues.

Behavior

Some of the respondents mentioned the influence of the price for the costumers and their attitude towards repair. It was pointed out that there are customers who can afford expensive repair, which can be understood as the official repairs offered which tend to be more expensive because the s[are parts are original. There are those who prefer lower cost and alternatives such as the independent repair. Among the independent repair sector there are of spare parts with different quality, thus, the most accessible parts are those with the lowest.

Types of Repair and Components Most Commonly Repaired

Fast repairs are the most common type of repair, in which screen changes, battery and charging points were the most common. All the repair shops can perform this basic repairs, even if the seller of the store doesn't know how to perform, it was noticed that there is some type of networks, which will be explained in more detail in its corresponding section. Slow repair can be understood as those that take more labor hours to be repaired due to the complexity and therefore it requires a technician with a higher level of expertise and knowledge.

Technicians

It was identified that there are two types of repairers in the independent repair sector. The first group is formed by those who know the basic repairs such as screen change. The second group is those who have studied and have the knowledge to repair complex components such as the motherboard of mobile phones. Those repairs that are more complex are sent to a laboratory to be repaired by technicians (Respondent 6). There are networks between shops and they bring devices to the technicians. The way how this type of network function is by means of contacts, basically, those who own a repair shop but doesn't have the technical knowledge to repair, they take the devices to other repair shops with people who know how to perform repairs. Also, it was observed that there are some shops in which the owner is a technician with high level of expertise and they don't sell accessories, they only receive phones brought by consumers, but also, they receive a lot of phones brought by means of the existing networks.

As it was identified in the field research, there are many accessories shops that offer repair to the public, but doesn't have a repairer or technician. In this cases, the established repair shops play a fundamental role.

Certification of Repairers

Most of the repairers interviewed replied that they do not have any type of certification in Europe (Respondents 2, 5, 9, 11, and 13). However, they mentioned having years of practice instead since it was frequently mentioned that they have learned their skills through practice (Respondents 2, 9, 11, and 13). Respondent 13 mentioned that no one checks for certifications, while Respondent 2 mentioned that he would get the certification only if the law requires it. One respondent mentioned having official certification from foreign countries (Respondent 13). Regarding this section, it was observed that whether they have it or not, independent

repairers learn to repair by means of empirical practice. It was observed that in one repair shop there was an apprentice learning from the expert technician.
It was mentioned that it was mentioned that it was very easy to learn by watching YouTube videos in which its explained step by step how to repair some devices.

Knowledge and Experience

Many of the independent repairers learned how to repair in their country of origin, mostly outside of Spain, since most of the interviewees are foreigners (Respondents 1, 2, 5, 7, 12, and 13).

This section is quite interesting since most of the interviewees have acquired knowledge and practical experience through 8, 10, 6, 6, 5 years of working in this sector (Respondents 2, 5, 9, 11, and 13 respectively). It was noticeable to the researcher that this experience had given them a lot of practice.

Cost of the Repairs and Labor

The cost of independent repairs is cheaper than the official repairs (respondents 2, 4, 6, 7, and 9). As Respondent 7 stated plainly, "the official stores can't compete with us because we have cheaper costs" (respondent 7). It was found that the cost of the repair depends mostly on the cost of the spare part. This is a very interesting and important finding because, for instance, one high end device can cost 1000 euros or even more, in which in many cases, the phone is bought in different instalments over one year or even two, In case that the phone has any failure attributed to the functioning the producer has to give the legal warranty. However, in the case of carelessness of the client, the warranty could not be paid by the producer of the device. Thus, when consumers have to cover the cost of the repair. The official cost is much higher than the monthly payment.
Moreover, during the research a broken phone was taken to repair by the author of this thesis. It was observed that the original cost of the official repair was 150 euros to change the screen of the device. Whereas, the independent sector offered prices from 50 , 70 and 80 euros. In addition, a rapid service was offered since the screen could be repaired in a time range from 30 minutes to one hour.

Ecodesign

The opinion is divided among repairers regarding the difficulty of repair in recent devices and models. Some of the repairers mentioned that it is easier with new devices (Respondents 1 and 4) while the majority of interviewees answered that it is more complicated to repair these devices (Respondents 3, 7, 12, and 13). It was mentioned that there are common aspects that each brand has in their devices and that make it easier to repair since most of the models are similar within each brand (Respondents 6, 13). Respondent 6 mentioned the following: "There are some phones and components that are impossible to be repaired because of their fabrication and design. I mean, it's not impossible, but can be repaired only in a 60% not entirely fixed. "Companies put limits to avoid the repair by independents".

Spare Parts

The spare parts sold by some independent repairers are mostly coming from China and are not original models (Respondents 1, 12, 11, and 13). It is easy to obtain spare parts for recent models (Respondents 1, 2, 3, 4, 5, 6, 7, 9, 12, and 13) and sometimes on the same day (Respondent 2). There are wholesale retailers that provide the independent repairers with all those spare parts, and anything that cannot be found in the store can be found online (Respondent 3). However, it is complicated to get for the old devices. In addition, it was observed that the major spare parts shops that sell wholesale in Barcelona where operated by Chinese people.

Repair Associations

As it was mentioned by some of the interviewees, there are no repair associations in Madrid or Barcelona, the two cities visited by the researcher. However, there is something similar to networks for collaboration, in which if one repairer cannot provide a service(s), he can take the device to another and share the profits (Respondents 2, 5, 9, and 13). It wasn't found anything similar to those in Austria.

Repair Sector Situation

The repair sector is not very competitive (Respondent 1) and the amount of services required has decreased (Respondent 4). Additionally, one repairer mentioned that he stopped doing repairs because there were no clients (Respondent 8). Most of the repairers interviewed were men between 25 and 50 years old, who had their primary occupation in the repair shops. Only one of the repairers interviewed was originally from Spain, and the rest were from Pakistan, Bangladesh, and India. It was noticed that 3 of the repairers interviewed recently opened the repair shop. It was observed that in Madrid and Barcelona there are independent repair shops all over the city, however, in both cities there is one street in the center of the city where there are only repair shops operated by different people and more than 20 repair shops are located together. In this streets the repair networks are very helpful.

Repair Vouchers

The interviewers questioned about the repair voucher and mentioned that are not interested in accepting vouchers. Only one mentioned yes, if the government is involved. However, due to the fact that most of them where busy at the moment of the interview, the researcher did not have enough time to explain all the concept of, its functioning and its background.

Support to Repairers

It was found that there is no support from the government or any fiscal incentive to the independent repairers since none of the interviewees answered positively to this question.

5 Discussion

The main objective of this thesis was to analyze the multiple factors that have the potential to lead to more repair in Spain. For that reason, a qualitative method was used to research in two stages, the first was desk research and the second with field research through interviews with independent repairers in Spain. In addition, the findings of both stages of the research are commented in order to respond RQ1 and its sub-questions.

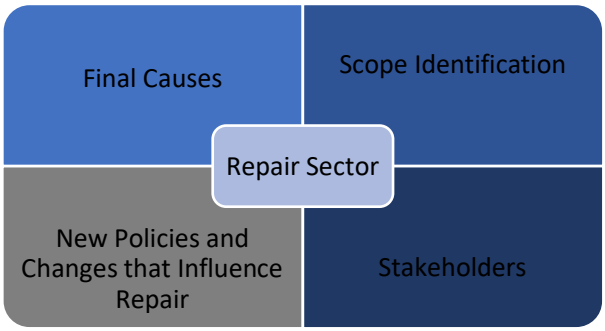


Figure 5-1 'Factors that Influence the Independent Sector Toward More Repair'

Source: Own elaboration

5.1 RQ1: How do the recent regulations and policies that are currently implemented, and those that are expected influence the independent repairers sector?

5.1.1 Final Causes

Once again, it's important to explain what is understood by final causes to avoid confusing the reader. Basically, this concept means, the objective, what is achieved by means of fostering repair rather than dispose. Since 2015, new policies and strategies have started to be promoted in the European Commission under the Circular Economy. In recent years, the proposals have gained strength and political support. One of the central points of these proposals is the extension of the lifespan of products. The current approach of the EU is to make the region's markets more sustainable, including for EEE (European Commission, 2022). The shift to a Circular Economy will bring new opportunities to several sectors, and especially to those who perform Circular Economy activities, such as repair. In the European Union as a whole and in each individual country, actions plan for the Circular Economy are being implemented to achieve one common objective, reducing the environmental footprint. The reason why the CE influences EEE and small ICT is because it has been identified by policymakers as one of the sectors that requires urgent action (European Court of Auditors 2021).

In the CE, waste reduction is one of the main objectives of the new proposals. Additionally, WEEE has become the fastest growing waste in recent years as it has been estimated in the Global E-Waste Monitor by Forti et al. (2020). For that reason, to reduce e-waste and its production, the Circular Economy has adopted a preventative approach (Puentes, 2021) in which those activities in the waste hierarchy that prevent waste further up the supply chain are preferred and will be fostered by different policies.

Together with the objectives to reduce the use of raw materials, the reduction of GHG emissions is very important for a CE since it is a direct consequence of the material extraction and exploitation which causes 50% of the emissions (European Commission, 2022). As the United States Environmental Protection Agency estimates in their WARM model secondhand, reuse, and repair are resource reduction activities.

To conclude this section, and to answer to RQ1, the Circular Economy addresses raw material and GHG reduction and for that reason, special attention is put to electronics sector, small ICT, and specifically mobile phones, due to the significant environmental impact caused during the production phase, thus to achieve this objective, there are many policies and regulations that have been deployed, however need to be enforced tenaciously, to be put in practice and not be forgotten in theory.

5.1.2 Scope Identification

The functionality of mobile phones has been increasing with time and the use of raw materials in its components as well (European Commission, 2020). A single phone contains raw materials in small quantities (European Commission, 2021), however, since the number of mobile phones produced is increasing every year, the total consumption of raw materials on these devices require in one year is enormous. For instance, in a tone of mobile phones, more gold can be found than in a gold ore (PACE, 2019).

Additionally, the number of devices sold every year has been exponentially growing (Valero, Calvo & Valero, 2021). The use phase of this small ICT is 2 or 3 years on average (European Commission, 2021), which means two things: (1) that at the end-of-life, all the raw materials can be lost if the electronics are not collected appropriately; and,(2) that new devices will be purchased to replace the old ones. Moreover, small ICT has been reported to be the category with lowest collection rates since there is a tendency to store them due to the data stored in the memory (ERP, 2020).

For that reason, mandatory ecodesign standards can be suitable for this type of products, which may not be applicable to all goods (Dalhammar, Milios, & Richter, 2021), but are a particularly good idea for mobile phones. These devices are explicitly considered in many regulations, policies, and movements. For instance, one of the electronics outlined in both the French and Spanish repairability indexes is the mobile phones. Under the Right to Repair movement, the repairability of mobile phones is being pushed more than other electronics due to its fundamental role in society and the frequency of its use. The ecodesign requirements of current legislative trends on this topic are pointing towards more repairability to extend the lifespan of mobile phones or to have the possibility of giving a second use to these devices.

To conclude, and to answer RQ1, mobile phones have been identified as a product that require regulation, and for that reason, recent ecodesign requirements and the new law adopted in Spain aim to impact the repairability of phones. As Puentes (2018) and Dorado (2018) calculated, Spain is one of the countries with the most mobile phones per inhabitant. Additionally, Ertz et al. (2019) found that mobile phones are the type of device most commonly repaired. Moreover, during the field research for this thesis, it was observed that in Barcelona and Madrid, the most common repair shops of electronics are those for mobile phones. Thus, it can be expected that this new regulations, policies will turn the direction towards more repair if are applied successfully.

5.1.3 New Policies, Laws, and Movements

The Right to Repair movement has gained strength in the US and the EU since its beginnings in 2014 and still now. As it was briefly mentioned in the previous section, mobile phones have been included as one of the devices regulated under the new legislative proposals, in both the EU and Spanish contexts. The aspects related to repair are found in different EU directives and policies:

Figure 5-2 'Different Directives and Policies that Influence the Repair Sector'

Source: Own elaboration

In the literature review, the cost of repair was identified as a decisive factor for repair (Ertz et al., 2019; Sonego et al., 2022) since consumers are not willing to pay high prices for repair services. In line with the aforementioned research, it was confirmed in the interviews with independent repairers that consumers are not willing to pay much for repair. This is an important consideration for independent repairers as their services and spare parts are typically cheaper than those of official repairers.

For many years, producers have limited access to repair (Maitre-Ekern & Dalhammar, 2016) by different methods and so current movements and proposals, such as the Right to Repair and Circularity , are supporting easier access to repair. Some of the barriers created by producers are being diminished under the right to repair proposals since, for instance, the availability of spare parts is going to be required as well as the compliance with ecodesign obligations in which repairability is considered. For that reason, some of the most common causes of repair of phones will be easily fixed, such as battery or screen replacement. The interviews with repairers confirmed the findings of literature review that the most common repairs are related to battery and screen change, for which the access to spare parts is extremely important. In addition, in line with the findings of (IIIEE & EEB, 2021) regarding the time taken to repair, it was found that most repairs are fast, and furthermore, the factor that can delay or extend the time is if spare parts are required. In the new ecodesign proposals regarding the requirements for smartphones, the access to spare parts is regulated with the purpose of easing access to them and allowing for more repair of mobile phones. The spare parts that are required to fix the most common failures are regulated under the requirements for smartphones on the proposals for the new ecodesign requirements. This environmentally friendly policy on design has proven to be a policy that can benefit all sectors involved in the electronics sector under the Circular Economy (European Commission, 2022).

Regarding the repairability index, Spain is about to implement it since it has been approved by the legislature. This index is adapted from French policies and is under revision after a process of public consultation. The criteria evaluated under the repairability index are documentation, disassembly, availability of spare parts, price of spare parts, and product-specific aspects. Previous examples of successful labels were analyzed in the literature review, such as the energy

efficiency label, and thus, it can be expected that the repairability index will have a positive effect in the mid-term. The aforementioned time span is determined because, as it was reported in the *Inception Impact Assessment on Ecodesign and Energy Labelling* (2020), developed by the European Commission, consumers tend to replace their mobile phones every 2 or 3 years.

It was found through the literature review that ecodesign requirements have the potential to reduce the number of mobile phones placed on the market by 2030 (European Commission, 2021; IIIEE, 2021). This means that ecodesign will contribute not only to the extension of the product's lifespan from improved durability, but also to its repairability as well, which will potentially benefit the independent repairers sector specifically. As it is analyzed in the Strategy 4 contained in the *Compendium about Circular Economy* (IIIEE, 2021), a good design can lead to the reduction of components, but also decrease the price of professional repair and even allow the customers to repair by themselves. In addition, different policies are being pushed and modified to incentivize ecodesign, such as EPR schemes or fiscal incentives.

The criteria considered in the Index can have a direct influence on the independent repairers sector since each of them can benefit not only the consumers but the independent repairers as well. For instance, all those mobile phones with higher score under the repairability index might be potentially highly repairable by both official repairers and by independent repairers. It is important that the policymakers stay updated on the latest information and research on this topic since it is continuously evolving and it would not make sense to create a different repairability index (Dalhammar, 2022).

Incentives to producers that follow the ecodesign requirements and levies have to be considered to those producers with the less environmentally friendly models and designs. Also, it is important to consider fiscal incentives to Circular economy activities. For instance, one example identified is the VAT reduction that positively affects repair (Milios, 2021). Additionally, subsidies, such as the Repair Voucher implemented in Austria, can help to encourage behavior towards repair (Almen et al., 2021). It was identified through desk research and confirmed in field research that in Spain, there is currently no formal support to independent repairers, and none of the interview respondents replied positively when asked about it.

The Right to Repair movement is currently fighting against obsolescence and its different types. As the European Environmental Agency (2021) argues, the types of obsolescence cause shorter product lifespans and contribute to the continuous purchase of goods. Practices that lead to obsolescence are being prohibited in some countries, such as France, and recently, the European Commission (2022) announced that it will prohibit such practices. Regulations on programmed obsolescence will lead to longer lifespans of products and more repair.

As it has been mentioned previously, to promote repair, a well-designed policy mix is necessary and a variety of policies on repair are currently being deployed. For that reason, different policies have to be implemented through the different stages of the lifecycle. For instance, the proposals on Pre-market Producer Responsibility (PPR) will lead to increased repairability of new devices placed on the market and the Extended Producer Responsibility (EPR) will lead to better management at the end-of-life stage of EEE, since devices collected can have a second life by means of preparation for reuse. The proposals of the Pre-market Producer Responsibility by Maitre-Ekern (2021) are well in line with the proposals of the Right to Repair movement. Extended Producer Responsibility schemes can provide incentives by means of modulated fees.

This can be particularly beneficial in the case of Spain, because 96.6% of the producers in Spain are affiliated to collective systems (Recyclia, 2021).

5.1.4 New Regulations in the Spanish Context that Improve Rates of Repair

In Spain, the Circular Economy strategies have led to the approval of several legislative changes that have been implemented recently to encourage consumers toward more repair. The prevention of waste is one of the pillars of the Circular Economy and one of the main actions included in the *Action Plan for the Circular Economy (2021)*. For that reason, the legal framework for EEE has been under revision. Legal provisions considering the extension of the legal warranty from 2 to 3 year and provisions of spare parts for 10 years were mandated in the General Law for the Defense of Consumers. The extension of these guarantees leads to more repair but, according to the contractual laws, the repair has to be carried out by official repairers and not independent. However, the access to spare parts will also benefit consumers and independent repairers.

The new *Law on Wastes and Contaminated Soils* includes requirements and legal provisions aimed to preventing waste by means of extending the lifespan of products through repairable designs and circular activities such as repair. Therefore, this new law is well in line with the Spanish Circular Economy plans. As well, it is important to note that this law contains the first official steps by the Spanish government towards adopting measures to avoid premature obsolescence.

This new *Law on Wastes and Contaminated* Soils also introduces ambitious targets for reparation for reuse, with the percentage of WEEE collected and prepare for reuse reaching 15% in 2035. Still, reuse and secondhand markets face many structural and social barriers in Spain. These challenges, such as improper care of collected devices by waste managers needs to be improved if Spain is to adequately implement its Circular Economy initiatives. In regard to repair, lack of spare parts has been a major issue in recent years (Bovea et al., 2015). Preparation for reuse of old devices in good condition can benefit the independent repairers sector for a few reasons. Firstly, collection of these old devices can provide important spare parts and strategic materials for reuse, thus also closing these material loops. Secondly, after collected devices are inspected for quality, they can be repaired and sold in the independent repairers shops. Many independent repairers are already facilitating the secondhand device market. Finally, by extending the lifespan of these products through reuse, consumers can slow the loops.

5.1.5 RQ1.1: What policies can be implemented in the independent repairers sector in Spain in order to benefit this sector? What role can the independent repairers play towards the achievement of the expected goal, and how can they be involved and incorporated?

This question is answered through the literature reviewed during the desk research phase and the data that emerged through the field research phase of this process.

Repair Networks

Firstly, it was identified that repair associations and networks have been created by repairers in Austria (Almén et al., 2021). These repair associations provide benefits to repairers, such as participating in the Repair Vouchers and accessing spare parts (Almén et al., 2021). In the cities visited in Spain, the interviewed repairers were asked about such associations/networks, however, was it was found that the associations that do exist are far from being as extensive as those in Vienna. Mostly commonly, the associations described by the interviewees are agreements between a couple of repair shops that are closely located geographically, wherein

they support each other by providing parts and services. For instance, if one repairer cannot carry out a specific repair, (s)he can send it to the other's repair shop.

Repair Vouchers

In Austria these vouchers are an incentive for consumers to repair more since they receive once a year voucher per household which is valid up to 100 euros, paid to the repairs by the municipality (Almén et al 2021) . In Spain, no such initiative or support was found in the research. Repairers that were asked about this were not interested in accepting this form of payment. However, the implementation in Spain has to be subject to further research.

Fiscal Incentives

Financial incentives to producers that follow the ecodesign requirements and levies, as well as Circular Economy activities, have to be considered. For instance, one example identified is the VAT reduction that positively affects repair in Sweden (Milios, 2021). The appropriate implementation of incentives can foster a consumer behavior towards repair (Almén et al., 2021). It was identified through literature and interviews that currently, in Spain, there is not this type of support to independent repairers and none of the participants replied positively to the question.

Secondhand

Devices can be repaired and sold in the independent repairers shops. Many independent repairers are already facilitating the secondhand device market. Spain has set ambitious targets for preparation for reuse by 2030 (15%) (Spanish Government, 2022) . Thus, independent repairers can maximize profits if they are incorporated adequately in the secondhand market. Further research has to be carried out since to uptake secondhand, it is important to first work to improve consumer attitudes and behavioral response toward the use of secondhand devices.

Certification

One of the aspects that influences the independent repair sector is the quality of the repair. Increasing the confidence in independent repairers and their services is important to increasing the total rate of repairs. France is certificating repairers by means of the EPR schemes (Dalhammar, 2022). Certification can help independent repairers to access the necessary information from official repairs, grow their customer base, and, in addition, it can provide more reliability on the secondhand goods repaired by them. As it was observed, most of the independent repairers interviewed did not hold any certification valid in Spain, but some did have foreign certifications. It should be noted that the repairers mentioned that no one checks about the certifications. Nonetheless, the respondents tended to have between 5 to 10 years of experience each in performing repairs and have gained a lot of expertise.

In addition, the certification on the independent repairers can include aspects related to data security and information. Currently, in our phones we have a lot of important information, from access to social media, conversations, directions, money and access to bank accounts, among many others. During a repair service with official stores people use to think and assume that is more secure. However, in case of the independent repairers, trusting in an unknown person to handle this type of devices is not always easy, in despite of the honorability, the clients don't know them and don't know about their honesty and intentions once they have the phone and once, they have access to their personal information. For that reason, the certification should guarantee this aspects as well and not only the technical aspect related to the quality of the service.

5.2 RQ1.2: What is the attitude of the repairers toward the new proposals?

This research question is answered with the data obtained through the field research in Spain. In short, the answer to this question is very simple due to the fact that only one of the repairers interviewed was aware of the current situation regarding the Right to Repair movement and the implementation of new policies, such as the Repairability Index. However, those that were informed during the interview showed an interest in it. A quick reflection can be done in this section, since it was found that the independent repairers, those who are actually involved in the repair activities, were unfamiliar with the current proposals, and thus, it can be assume that average consumers would not be any more familiar with these policies and initiatives.

5.3 RQ1.3: What is the current situation of the independent repairers sector in Spain?

To answer this research question, the data obtained by the desk research is combined with the findings of the qualitative research. It is important to note that the independent repair shops that were visited as part of the field research are small-scale local shops, owned by private individuals.

Among the independent repairers, two categories were identified: (1) the majority, who perform general or simple repairs, and (2) the minority, who perform more advanced repairs. Usually, those repairers who perform advanced repairs are members of the repair associations or networks identified in Spain. For that reason, they often repair mobile phones received by other repairers. The second category is usually designated as the "technicians". As it was observed during the field research, there is an abundance of repair shops, but a lack of technicians.

Regarding the new proposals on access to information that the Right to Repair movement, the European Commission, and the Spanish Congress are pushing, the independent repairers interviewed mentioned that it is not complicated to find the necessary information for repair since it is freely available online and, furthermore, those who are more experienced mentioned that they do not need the information. The second category of repairers can be benefited from the access to information more than the ones from the first category. Conversely to what was initially hypothesized, the field research and the analysis of data suggested that the access to information is not a barrier for independent repairers to perform most of the common repairs, such as battery and screen replacement, which make up a majority of their requests.

The independent repair sector has faced barriers to repair created by the producers and the closed access to repair. It was confirmed through the field research that intellectual property poses a barrier to independent repairers due to the potential legal consequences. However, despite of the aforementioned barrier, access to spare parts was not found to be an issue, since many of the respondents answered that it is very easy to access to spare parts and perform repairs of recent devices because there are wholesale stores that sell imitations, usually produced in China, that can be provided in minutes through the associations/networks. For the older models, it is more complicated, but still possible, to find spare parts as they often have to be ordered online and received some days later.

The issue about spare parts gets complex because, under the new policy proposals, it has been established that producers have to guarantee access to spare parts for either 10 years in Spanish legislation (Spanish Government, 2021) or 5 years in the ecodesign requirements for mobile phones (European Commission, 2021). Additionally, in the new proposals on ecodesign requirements for smartphones it was established that:

> "Manufacturers, importers or authorized representatives shall make available to professional repairers at least the following spare parts, including required fasteners, if

> not reusable, for a minimum period from 6 months after placing the first unit of a model on the market until five years after placing the last unit of the model on the market (…)"

The aforementioned provision raises one question: who can be considered a professional repairer? There are independent repairers that have acquired years of empirical experience from practicing repairs but don't have any certification.

Regarding the access to tools, the opinion is divided, as the majority of repairers that were asked mentioned that it is not a problem because, as with the spare parts, imitations can be obtained easily. However, was mentioned that more tools are required to appropriately conduct the repairs.

With regards to the design of mobile phones for easy repair, the opinion was divided among the respondents as well, since it was mentioned by some that new devices are easier to repair, while others mentioned the contrary. However, this conclusion is based purely upon their personal experiences, formed through the devices that were brought to them individually since each brand has different designs and models.

In another note, it was confirmed that the cost of repair is an important factor that influences the rates of repair of mobile phones. Despite that the new spare parts used by repairers are cheaper, consumers still being influenced by its cost. Furthermore, the cost of independent repairers is lower than those prices offered by official stores and this is the competitive advantage that independent repairers have. However, as a whole, the EEE repair sector is not very competitive. Regarding the cost of repairs, it was found that there is a distinction drawn between those consumers who can afford official repairs and those who only afford independent repairs, and thus a major factor that influences the decision to repair officially or independently is the price of the services and spare parts. It was found that many high-end devices are commonly paid for in installments, and for that reason, if some aspect fails or breaks, and is not covered under the legal warranty, the cost of repair is very high for some consumers, since the spare parts might cost more than a monthly installment.

The repairs performed by independent repairers are covered by a warranty offered by the repair shops that cover 3 or 6 months and include the spare parts used. Additionally, the wholesale stores of spare parts give a warranty to the independent repairer that use the product for a repair service. Consumers' confidence in independent repairers have to be increased to support this sector. As it was concluded, the major strength that this sector have is that the prices to repair are more accessible than the official cost and at the end the result is the same, extending the lifespan of phones and slowing the loop.

5.4 Methodological Considerations

A qualitative approach was adequate to research about this type of problem. The first stage of the review was particularly useful to gain knowledge and understanding of the current situation and the field research helped to validate and confirm some of the findings of the literature review. As well, the methodological approach used was particularly helpful to get emerging data.

Moreover, since face to face interviews were carried out by the researcher not all the repair shops in Spain were visited and the findings of these thesis can't be generalized. However, due to the methodological structure used some of the findings are clearly in line with the findings of the literature research. Under the method selected, interviews are an important factor to the findings, regarding the interviews it has to be mentioned that in most of the repair shops visited it wasn't possible to carry out interviews due to personal decision of repairers to not be interviewed and in some cases because the person in the store did not know how to repair.

An important consideration of the methodological preference is the self-bias, since the research consisted in two stages and the findings of the first could have influenced the findings of the second. The method selected can be used to continue the research and analyze other aspects and stakeholders to extend the knowledge in the future since this research raised new aspects that can be researcher and commented in the future research section.

Finally, a methodological consideration that has to be considered is that only the independent repairers sector was consulted by means of interviews since they are the population studied. However, other stakeholders position was considered in the analysis through the literature review.

6 Conclusion

The increase of the use of EEE, and in particular mobile phones, in our daily life styles has led to the imperative necessity to regulate its durability and repairability.

New approaches to production are being considered under the Circular Economy and the Right to Repair Movement to change consumption habits and extend the life span of electronic devices, and in particular, mobile phones by means of repair. As it was found in the research there are several barriers that have been created by producers and have hindered repair in the past years, however, recent laws and policies have diminished those barriers with the purpose of easing the access to repair. Additionally, several factors that influence the repair sector towards more repairs and repairability of electronics are analyzed through the main research question of this thesis.

RQ1: How do the recent regulations and policies that are currently implemented, and those that are expected, influence the independent repairers sector?
Since 2015, many new policies and strategies have emerged in the EU that promote the Circular Economy. These proposals often prioritize the prevention of waste and have identified small ICT (including mobile phones) as one of the sectors that requires urgent action. This is in part because mobile phones contain many strategic materials, including rare earth metals, which have a significant environmental impact from its production, including high greenhouse gas emissions produced from extracting and exploiting these resources. Circular Economy legislation, by promoting waste prevention activities, will necessarily benefit the repair sector.

The use of mobile phones has been growing in recent decades, which is particularly problematic because small ICT have some of the lowest rates of collection, often due to the so-called "treasure effect", wherein consumers store their device at home after its useful life to preserve the data stored within its memory. For these reasons, mobile phones are often outlined explicitly as priorities for ecodesign initiatives. Many of these ecodesign policies and directives will improve the repairability of mobile phones through mandating design for durability, modularity, and disassembly, among others.

As mentioned above, many different policies contain objectives and provisions that affect the repair of mobile phones. For example, the Repairability Index, which was approved by the Spanish government within the last year (2022) contains criteria on documentation, disassembly, availability of spare parts, and other, product-specific aspects. Other policy instruments, such as fiscal incentives, by means of tax reductions and subsidies, can further promote repair. A well-designed policy mix is crucial to address all stages of the lifecycle of EEE, from Pre-market Producer Responsibility (PPR) in production to Extended Producer Responsibility (EPR) in waste management.

Spain's *Action Plan for the Circular Economy* (2021) describes many of the proposed initiatives to improve circularity, and therefore, repair. For example, some provisions would extend the product warranty and availability of spare parts. Other current legislation also supports these objectives, including the *Law on Wastes and Contaminated Soils* (2022), which contains requirements for design and targets for reuse of these products. Therefore, these legislations would greatly benefit repairers by promoting (and even mandating) circular activities.

RQ1.2: What is the attitude of the repairers toward the new proposals?
In short, virtually none of the repairers interviewed were aware of the current policy landscape, but, upon learning more, all were in support of the initiatives. It can be assumed that consumers would not be any more aware of this context than those working in the field.

RQ1.3: What is the current situation of the independent repairers sector in Spain?
Independent repairers tend to be divided into two categories: those who perform the simple, more common repairs, and those "technicians" who can perform more complex repairs. In general, the repairers interviewed stated that the information for the most common repairs is freely and easily accessible online, and thus access to information was not a major barrier for their operations. However, intellectual property and the legal ramifications it poses are a limiting factor for many repairers. Opinion was divided among the respondents on whether or not access to spare parts and tools was a major issue. Finally, cost was identified (in the literature and in the interviews) as a deciding factor for many consumers on whether or not to repair. The independent repair sector generally has the competitive advantage over official repairers in this regard, but the repair sector as a whole is not very competitive.

6.1 Policy Recommendations.

The RQ1.1 is omitted from section 6 since the question answers to the policy recommendations.

RQ1.1: What policies can be implemented in the independent repairers sector in Spain in order to benefit this sector? What role can independent repairers play toward the achievement of the expected goals, and how can they be involved and incorporated?
Further expansion of the repair networks and associations would improve the distribution of information and the quality of repairs. In Austria, for example, these groups benefit (independent) repairers by including them in the Repair Voucher system and by facilitating access to spare parts (Almén et al., 2021). Such networks could support and enhance the repair sector in Spain. Additionally, fiscal incentives, such as the VAT reduction in Sweden (Milios, 2021), were supported amongst the independent repairers interviewed for this study. This is an area that is severely lacking in the Spanish context. Finally, it is crucial to change consumer attitudes toward reuse and repair. Certification of repairers or of secondhand products can guarantee quality to consumers. Furthermore, such a certification scheme would allow independent repairers access to information from official sources and even grow their customer base. However, this proposal is still in its infancy, as none of the repairers interviewed held Spanish certifications.

6.2 Recommendations for future research.

This thesis research allowed trough the literature review and field research to identify several topics that can be reviewed in the future to produce knowledge that can be helpful to policy makers. The following recommendations are related to the implementation of some of the policies that are proposed. Thus, it has to be researched how to implement fiscal incentives to foster repairs under Spanish administrative and fiscal scheme. As well, the implementation of repair vouchers in the cities visited can be subject to future research.

Regarding the access to spare parts, it has to be researched how does the right to repair movement and the access to spare parts that has been mandated in laws will guarantee the access to original spare parts to independent repairers. Moreover, it has to be researched about the supply of spare parts and its components in order to assess the possibility to use secondary raw materials. Certification schemes for independent repairers can be analyzed and researched in order to assess and evaluate the qualification of independent repairers in order to include them in municipal repair of electronics or in official stores.

The repair associations can be researched in order to create one association that benefits the local repairers taking into consideration the particular situation of Spain.

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Appendix A: List of Terms

Circular Economy (CE)
Closed access to repair
Durability
Durability index
Eco-design
Eco-labeling
Electrical and Electronic Equipment (EEE)
Electronic waste (or e-waste)
End-Of-Life (EOL)
European Union (EU)
Extended Producer Responsibility (EPR)
Gross Domestic Product (GDP)
Information and Computing Technology (ICT)
Independent repairers
Intellectual property
Light Electric Vehicle (LEV)
Lithium-Ion Battery (LIB)
Ministry of Consumption (MIC)
Modularity
Official repairers
Open access to repair
Original Equipment Manufacturer (OEM)
PESTEL analysis
Polluter pays principle
Precautionary principle
Pre-market Producer Responsibility (PPR)
Premature obsolescence
Preparation for reuse
Programmed/planned obsolescence
Producer Responsibility Organization (PRO/SCRAP)
Repair
Repairability
Repairability index
Repairer
Repair voucher
Reuse
Right to Repair Movement (R2R)
Servitization
Spare parts
Strategic materials
Take-back programs
Treasure effect
Value Added Tax (VAT)
Waste of Electrical and Electronic Equipment (WEEE)
Waste hierarchy
Waste management
Waste reduction
Waste Reduction Model (WARM)

Appendix B: Interview Protocol

Interview Protocol for the research study named:
Spain Toward Repair of Mobile Phones.

1. Purpose and objective

The purpose of this interview is to obtain data from the repairers and experts who work in the field to identify and track how is the process and progress of implementation of the new regulations and policies pushed by the National Government in accomplishment with the new EU regulations.

Since the repair topic has been evolving and at fastest speed in the last two years, there is a need to evaluate is there is knowledge that can emerge from the practitioners in the field.

This series of interviews allow the researcher to identify which policies are being implemented in Spain, regarding, eco design, access to spare parts, what type of government support is currently existing and what is the current environmental knowledge of the repairers.

Two different questionnaires where developed the first, to identify how is the current context due to the recent changes. The second, to understand the local context and the feasibility of the implementation of other policies implemented in other countries such as repair vouchers (Austria), tax deductions for repair sector (Sweden). The reason to develop two different questionnaires is because of time extension of the interviews. Thus, half of the interviewees responded the former and the other half the latter.

With the data obtained by qualitative methods, the researcher will be able to understand which is the actual role and situation of the policies and regulations towards repair. As well as analysing the data to identify current gaps that exist in Spain regarding the implementation of the Circular Economy in the repair of electronic sector and in specific for mobile phones.

The findings of the analysis will allow to develop policy recommendations.

2. Introduction

The researcher introduced himself and explain to the interviewee the purpose of the interview.

Since the interviews were performed directly in the repair shops, this information was explained directly. In addition, since the independent repairers where visited, previous preparation wasn't required.

The structure of the interview was explained before starting.

3. Consent Form

Participant's Name:
Interview Date:
Location:

Project/Research Title: Master Thesis on Policies to Reduce E-Waste

Description of the Project:
The main objective of this Master thesis research is to assess, firstly, the applicability of the new right to repair and suggest policies that can be used to support it. Secondly, the attitude of the repairer's sector toward the new right to repair regulation and eco-design.

The purpose of this interview is to discuss about the legal aspects related to the right to repair with an expert researcher in the topic.

- I confirm that my participation in this research project is voluntary.
- I understand that I will not receive any payments for participating in this research interview.
- I understand that I have the right to decline to answer any question or to end the interview at any point.
- I confirm that the research interview will last approximately 15-20 minutes.
- I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that my confidentiality as a participant in this study will remain secure.
- I agree that the researcher may publish documents that contain quotations by me.
- I may access, upon request, the notes, transcripts, and other data collected during this research interview.
- I have been given a copy of the consent form.
- I have read and understand the explanation provided to me.

By signing this form, I agree to the terms indicated above.

Participant's Signature

Date Signed: _____

Researcher's Signature

Date Signed: _____

4. Interview Guide A

Introduction	1. Can you please explain what type of repair activities are performed in this repair shop? 2. Is this your main occupation or do you have other? 3. Are you aware of the new policies and regulations regarding the repair of phones?
Ecodesign	4. In the last 2 years have you perceive any positive or negative change that influence the easiness to repair devices? 5. Is the time to repair being reduced? Less labor hours to repair? 6. In the case that repair is faster and easier, would you reduce the price of the repair to consumers?
Spare parts	7. Is it easier to access to spare parts? Is there any specific brand that is easier or complicated to access to spare parts and tools? 8. What are the most important barriers when you want to repair a device?
Information	9. How did you obtain the information and manuals to repair? 10. Have you perceived any difference on the accessibility to information?
Support from government and producers	11. Is there any support from the government? Is there any fiscal incentive or tax deduction? 12. When opening the repair shop, is there any support? 13. Is there any company that support access to repair by any mean?
Repairability index	14. Have you heard about the repairability Index? How do you expect this to influence your business?
Environmental knowledge	15. What do you think about the raw materials contained in the phones?

4. Interview Guide B

Introduction	1. Can you please explain how did you acquired the knowledge and expertise to repair phones? 2. How long have you been performing repairs? 3. Have you heard about the Right to Repair movement? If yes, what?
Repair associations	4. Is there any repair association? If yes, what are the main benefits of being member? If not, would you be interested in forming part?
Spare parts	5. In the situation that you have better and cheaper access to spare parts, would you reduce the cost of your services to repair? 6. Do you obtain spare parts directly from the producers or is there a thirds party that provides the parts?
Information	7. Would you be interested in paying a annual fee for accessing to information? 8. Is there any company that facilitate access to official information?
Certification	9. Do you have any certification to repair? If yes, how did you obtained it? 10. If not, would you be interested in getting certified?
Alternatives	11. Would you be interested in accepting repair vouchers? (Explanation about the concept is given to the interviewee) 12. Would you receive an old phone in exchange for services or reduction in costs of the repair?
Repairability index	13. Did someone consult you about the repairability index? In your opinion what are the advantages of this informative labeling?
Extension of legal warranty	14. Which do you think that is the benefits of extending the legal warranty of products from 2 to 3 years?
Environmental knowledge	15. What do you know the relationship between mobile phones and the environment?

Appendix C: List of Codes Used in the Qualitative Analysis

Name	Files	References
Access to information	9	15
Alternative payment	3	3
Awareness	10	11
Barriers	5	6
Battery, Charging, LCD, camera, motherboard	2	2
Certification	5	8
Cost of repair	10	15
Ecodesign	7	14
Intelectual property	3	4
Knowledge, experiece, qualification	9	22
Main occupation	7	8
New repair shops	1	1
Raw materials	1	1
Repair associations	4	5
Repair sector situation	3	3
Repair Voucher	3	3
Repairability index	9	10
Service	2	3
Spare parts	11	25
Support to repair	6	16
Technician	4	6
Tools	3	3
Type of repair	6	7
Warranty	2	4