Upscaling Electronics Repair to Support a Circular Economy in Sweden:

A Focus on Cellphones Through the Lens of Policy Intervention

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Abstract

E-waste is a growing waste problem around the world, and Sweden is no exception. However, the Swedish WEEE system is having issues combating the problem – particularly when it comes to cellphones. The aim of this research is to develop an understanding of the Swedish WEEE system in practice when it comes to cellphones, to explore what benefits actors in the Swedish system reap from choices to repair or recycle cellphones, and to gain an understanding of which actors receive those benefits from repairing or recycling cellphones in Sweden. This research was in collaboration with the Swedish Ministry of the Environment. My three research questions were: (1) *How does the Swedish WEEE system function in practice when it comes to cellphones?* (2) *What benefits do actors in WEEE gain from participating in the repair of cellphones vs the recycling of cellphones?* and (3) *What actors benefit from choices to repair cellphones vs recycle those cellphones in Sweden?* The methods of data collection were semi-structured interviews and audio-visual materials. I collected interview data and web-materials. My methods of data analysis were synthesis matrixes and computer-assisted content analysis. My study had 11 thematic findings. When these findings were put into the context of existing research, I made several insights: **(1) When it comes to phones, Sweden's WEEE system is complicated, (2) Understanding of the phone repair benefits-actors dynamic has been improved, (3) Understanding of the phone recycle benefits-actors dynamic has been improved.** And lastly, I found that actors are invested in **(4) The future of repair and overcoming obstacles** to repair. In conclusion, Sweden's WEEE system is complicated, as are the dynamics surrounding "benefits and actors" in phone repair and recycling. Future research could explore what complex value actors in the Swedish WEEE system gain from recycling cellphones vs repairing them.

298 words

Keywords: Sweden, cellphone repair, cellphone recycling, benefits, actors, circular economy, policy intervention

Executive Summary
(1) The Problem Definition

Background

Around the world solid waste production has increased. Approximately 11.2 billion tonnes of solid waste is collected annually worldwide (U.N. Environment Programme, 2017). Furthermore, natural resources are being consumed at a higher rate, with resource use exceeding local availability thus heightening environmental impact (European Environment Agency, 2019). E-waste is a growing waste problem around the world, and Sweden is no exception. In 2014 global e-waste production totaled 41.8 million tonnes (Cole et al., 2019).

In Sweden, e-waste management is guided by national and EU policy, one of the most prominent of which is the EU WEEE Directive that came into force February 2003 (Ivert et al., 2015). Sweden has one of the highest rates of WEEE collection in the EU, in 2017 14.1kg of WEEE was collected per inhabitant in Sweden, as compared to the lowest rate of collection of 2.4 kg per inhabitant in Romania (Eurostat, 2021). However, even here still, WEEE management is difficult – Sweden has been falling short of its WEEE directive obligations (European Commission, 2019).

Policy measures have been identified by researchers as a promising way to solve Sweden's WEEE issue (Almén et al., 2020; Dalhammar et al., 2020). In 2020, the Swedish Government published a new national circular economy strategy. In its "Priority streams in the transition to a circular economy", the government explicitly identifies the importance of leveraging WEEE collection to further increase collection, to engage in small electronics deposit refund systems to encourage collection, and improve product design to ultimately decrease the number of devices circulating (Government of Sweden, 2020).

Problem definition

However, despite iterations of the EU WEEE Directive addressing the complex WEEE stream, recycling dominates as the preferred management strategy in the Directive (Cole et al., 2019). This disruption of the waste hierarchy through policy measures undermines the long-term goal of achieving a more circular society. It instigates a sub-optimal utilisation of resources by forgoing the opportunities to increase product longevity, repair and reuse (Cole et al., 2019). This recycling over repair dynamic is then reproduced in Sweden, as Sweden is subject to the WEEE Directive.

The existing research also showed that there are more barriers to repair as compared to barriers against recycling in Sweden (Albergotti, 2020; Almén et al., 2020; Cole et al., 2019; K. A. Whalen et al., 2018). The review of existing literature also revealed that knowledge pertaining to which actors benefit from the choices to repair or recycle, and how, was scant. The lack of a discussion around what construes benefits around repair or recycling, who experiences them and how, warranted further research. The persistent knowledge gap presented an opportunity for thesis research that can contribute to addressing it.

(2) Aim and Research Questions

The aim of this thesis research is to develop an understanding of the WEEE system in Sweden in practice when it comes to cellphones, to explore what benefits actors in the Swedish system reap from choices to repair or recycle cellphones, and to gain an understanding of which actors

receive those benefits from repairing or recycling cellphones in Sweden. It is the intention of this study that this knowledge (embedded in the wider theme of sustainable development) is used by the Swedish Ministry of the Environment (with whom I am collaborating with) to further efforts to achieve a circular economy in Sweden.

Three research questions were explored:

1. *How does the Swedish WEEE system function in practice when it comes to cellphones?*
2. *What benefits do actors in WEEE gain from participating in the repair of cellphones vs the recycling of cellphones?*
3. *What actors benefit from choices to repair cellphones vs recycle those cellphones in Sweden?*

(3) Research Design, Materials and Methods Used

The **methods of data collection** were semi-structured interviews and audio-visual materials.

Regarding the **materials** I collected, I conducted interviews with **6 experts** in Sweden's WEEE system. These experts were comprised of:

1. A CEO and Managing Director from a large Swedish Waste Management and Recycling Association.
2. A CEO from a significant Swedish Waste-to-Energy company.
3. A Vice-President of Business Development from a major Swedish PRO.
4. A Business Specialist from a large Swedish Recycling company.
5. A Researcher in extended producer responsibility and Swedish WEEE policy at a significant Swedish industrial environmental economics Research Institute.
6. A Researcher and Project Manager from a major Swedish environmental Research Institute.

I collected 10 web-materials (6 online webinars, 2 online conferences and 2 podcast episodes) from which I gathered the perspectives of **28 experts** in the field of Swedish and European WEEE management.

With an extensive group of **34 experts**, my data was gathered from the stakeholders who arguably know the most about Sweden's WEEE system as a result of centrally participating in it.

My **methods of data analysis** were synthesis matrixes and computer-assisted content analysis (NVivo 13).

(4) Main Findings

My study's thematic findings are summarised in *Figure (i)* further below. Each finding is tagged with the research question it correlates to.

When these thematic findings from my study were comparatively analysed to the existing body of literature, I made several insights. Firstly, I found that **(1) When it comes to phones, Sweden's WEEE system is complicated.** Sweden's WEEE system involves many actors, to the point that the boundaries of the system are hard to draw. These many actors perform complex, interrelated and sometimes overlapping roles in the waste management of cellphones. Furthermore, the study showed that WEEE actors' roles evolve over time. In practice, this evolution modifies the practical distribution of responsibility outlined in Sweden's formal

WEEE policy. Lastly, cellphones are a complex device with a complex value chain of actors. This value chain of actors must then interact with the many actors in Sweden's WEEE management system.

I also found that **(2) Understanding of the phone repair benefits-actors dynamic has been improved.** Phone repair is deeply complex as a service that actors offer to society *and* as a role that actors execute in the WEEE system. In order to upscale phone repair, legislation, economic factors, and the technical landscape must align and support each other. The value that actors get from repairing phones is also complex, because it's hard to measure and all value is interconnected. Here, I propose the terms *complex benefit* and *complex cost* as part of our understanding of the concept of complex value. Complex benefit and complex cost need to be understood so that we know how to push actors towards phone repair.

I also found that **(3) Understanding of the phone recycle benefits-actors dynamic has been improved.** Some actors have strong incentives to uphold the premature recycling of cellphones. These incentives include established technological infrastructure, legislation supporting recycling and economic drivers. The more we learn about this knowledge gap, the more we know how to encourage recyclers to push for more circularity.

Figure (i) Thematic findings from the research study. All images used are Copyright Free and Creative Commons.

Main findings

- **(RQ1) There are many actors involved in Sweden's WEEE system when it comes to phones, some of them are obscure.**
  - **(RQ1) Role evolution is critical to WEEE actors remaining viable.**

- **(RQ1) There are several good features of the SE WEEE system that allow it to be successful when it comes to phones.**

- **(RQ1) There are also several negative features of the SE WEEE system that either cause problems or limit success when it comes to phones.**

- **(RQ1) Cellphones are unique as an electronics group.**

- **(RQ2 and RQ3) There are multiple benefits, costs, and incentives for phone repair being experienced by different actors.**
  - **(RQ3) Repair has to make economic sense for actors to engage in it.**

- **(RQ2 and RQ3) There are multiple benefits, costs, and incentives for phone recycling being experienced by different actors.**
  - **(RQ2) The challenges encountered during phone repair can present opportunities for phone recycling.**

- **(RQ3) Actors face various barriers and conflicts in engaging the recycle-to-repair transition.**

- **(RQ3) Actors are thinking of various future solutions and innovative changes to the WEEE system that can increase phone repair.**

Lastly, I found that actors are invested in **(4) The future of repair and overcoming obstacles** to repair. Despite some actors being locked in by investments in recycling and others facing barriers to their repair efforts, many actors are still developing and implementing solutions to increase the circularity of phones as an electronics group in Sweden.

(5) Conclusions and Recommendations

My three research questions could be answered as follows:

Answer to RQ1: Sweden's WEEE system is organised according to an Extended Producer Responsibility approach that is legally mandated by law through the EU WEEE Directive. Each actor performs a role in this system. Several good features of Sweden's WEEE system allow it to be successful, but negative features of Sweden's WEEE system still cause problems.

Answer to RQ2 and RQ3: My research was able to determine the benefits, costs, and incentives a limited group of 6 actors experienced when they engaged in repairing cellphones. For recyclers, repairers/refurbishers, PROs, producers, consumers, network service providers and retailers I was able to identify economic, legal, social, and environmental costs, benefits, and incentives for phone repair. My research was also able to determine the benefits, costs, and incentives a limited group of 4 actors experienced when they engaged in recycling cellphones. For recyclers, PROs, producers, and consumers, I was able to identify economic, legal, social, and environmental costs, benefits, and incentives for phone recycling.

For my target audiences (1) my peers and instructors from the Environmental Management and Policy Master's program, (2) The Swedish Ministry of the Environment and (3) Actors involved in electronics repair activities for a circular economy in Sweden, I provide a list of both short-term and long-term recommendations.

Future research could look to explore the following research question: *What **complex value** do **actors** in the Swedish WEEE system gain from recycling cellphones vs repairing them?*

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Abbreviations

CE – Circular Economy

EEE - Electrical and Electronic Equipment

EPR - Extended Producer Responsibility

EU – European Union

PRO(s) - Producer Responsibility Organization(s)

SE – Sweden

WEEE - Waste Electrical and Electronic Equipment

1 Introduction

In this chapter I will present my research problem, research aim and research questions, research ethics and target audience.

1.1 Delineation of topic

1.1.1 The Policy context

Around the world, electronics have become an integral part of everyday life. As a result, the appropriate waste management of these devices is also a part of regular life. The Swedish government has identified that the appropriate management of WEEE is central to achieving circular economy objectives (Government of Sweden, 2020). To that end, it is important to note that over the past several decades several policy interventions have been leveraged at the international, EU and Swedish level to tackle the WEEE problem:

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

For a long time on the international stage, over the years there have been multiple policy interventions that are associated with the WEEE problem on the global scale (Sverige & Naturvårdsverket, 2011). As summarised by Sverige & Naturvardsverket (2011), Widmert et al (2005) listed more than 14 international initiatives to deal with global e-waste. With such earnest efforts over a long period of time, the trouble of global e-waste has been an ongoing problem for a long time.

The Basel Convention was created to deal with the problem of rich countries transporting and dumping hazardous waste in poor countries as a result of economic incentives (Sverige & Naturvårdsverket, 2011). The Basel Convention entered into force in 1992 (Secretariat of the Basel Convention, 2011b). Sweden is a party to the Basel Convention, ratifying in 1991 and entering into force in 1992 (Secretariat of the Basel Convention, 2011b). Being considered a toxic material, the transboundary movement of WEEE is indeed regulated by the Basel Convention (Widmer et al., 2005). Among other developments, in 2002 and 2009 the parties to the Convention initiated agreements with key stakeholders and cellphone manufacturers to engage and encourage environmentally friendly end-of-life waste management of their products (Sverige & Naturvårdsverket, 2011). The Mobile Phone Partnership Initiative (MPPI) was launched in 2002 and adopted by the Parties as an effort towards promoting better WEEE management as it pertained to mobile phones and (among other objectives) encouraging reuse, refurbishing, material recovery, recycling and greener disposal of mobile phones (Secretariat of the Basel Convention, 2011a).

The EU WEEE Directive

As a member state of the EU, Sweden is subject to the EU WEEE Directive. The EU WEEE Directive was put into force in February 2003 and legislated the concept of extended producer responsibility in the EU (Ivert et al., 2015). In December of 2008, a revision was proposed by the European Commission to deal with the growing WEEE stream and was subsequently put into effect in 2014 (Ivert et al., 2015). The directive covers 10 categories of electric products, including (but not limited to) IT devices, household appliances, and leisure equipment (Ivert et al., 2015).

In the EU, the Directive is part of national legislation of member states. For Sweden which is part of the EU, the current WEEE directive is incorporated into law and was entered into force

in October of 2014 (Ivert et al., 2015). In the case of Sweden, the WEEE Directive is implemented into national Swedish law as "Förordningen om producentansvar för elutrustning, 2014:1075" (Ivert et al., 2015). (Google Translation: "Regulation on producer responsibility for electrical equipment"). In the Ordinance issued by the Ministry of Environment, Section 44 details that when electrical equipment become WEEE, the entire device and its parts are subject to the EPR conditions described throughout Sections 40 to 42 of the law (Riksdagsförvaltningen, 2021).

In Sweden, the waste management policy is grounded within the waste hierarchy as defined by the EU (Swedish Environmental Protection Agency, 2009). Producer Responsibility Organisations, or PROs, are key actors in Sweden that allow producers to fulfil their obligations under the WEEE Directive. As of 2001 and by agreement, El-Kretsen is a PRO in Sweden that represents producers of electronics on the Swedish market (Swedish Environmental Protection Agency, 2009). Where PROs bear all other costs of proper WEEE management, municipalities, producers and companies (e.g. retailers) in Sweden collect waste electronics (Swedish Environmental Protection Agency, 2009). Through the functions of the PRO actor in Sweden's waste management system, Swedish authorities can ensure that waste electronics in Sweden are treated according to the WEEE Directive (Swedish Environmental Protection Agency, 2009).

The Swedish Circular Economy Strategy

Adopted by the Swedish Government in December 2020, the Swedish circular economy strategy for the transition outlines an ambitious long term plan for Sweden's transformation into a circular society (European Circular Economy Stakeholder Platform, 2019). In its "Priority streams in the transition to a circular economy", the government explicitly identifies the importance of leveraging WEEE collection to further increase collection, to engage in small electronics deposit refund systems to encourage collection, and improve product design to ultimately decrease the number of devices circulating (Government of Sweden, 2020). Extending product lifespans, making products easy to reuse and repair, internalizing the externalities involved in product production and encouraging resource-efficient, non-toxic design and circular product design (Government of Sweden, 2020) are just some of the government's explicit focus areas for achieving sustainable production and product design – key components of the WEEE problem. The strategy also makes explicit the importance of increasing reuse and recycling in electrical products as an explicit 'stream of interest' (Government of Sweden, 2020).

1.1.2 Background on the WEEE problem and its Significance

To understand the significance and importance of electronics repair in Sweden, it is important to explore the issue from a general-to-specific lens. Around the world solid waste production has increased. Approximately 11.2 billion tonnes of solid waste is collected annually worldwide (U.N. Environment Programme, 2017), posing a challenge for waste management systems and underutilizing material with value beyond 'waste'. In Europe, waste generation saw an increase of 3% between 2010 and 2016, amounting to more than 70 million tonnes (European Environment Agency, 2020). Furthermore, natural resources are being consumed at a higher rate, with resource use exceeding local availability thus heightening environmental impact (European Environment Agency, 2019). A concurrent problem is that these resources are then underpriced, allowing over-extraction at unsustainable prices and diminishing incentives to manage resources well (Government of Sweden, 2020).

Waste electrical and electronic equipment (WEEE) is a growing waste stream around the world that is becoming of increasing concern. In 2014 global e-waste production totaled 41.8 million tonnes (Cole et al., 2019). The EU's WEEE Directive has through multiple iterations attempted

to address this issue, however recovering and treating WEEE is difficult due to its toxicity, quantity, heterogeneity, and composition that includes critical metals (Cole et al., 2019; Ekberg et al., 2020; Widmer et al., 2005). In Sweden, 88% of electrical and electronic equipment (EEE) was collected and reported from the waste generated in 2010, as compared to 68% collected and reported in 2015 (Urban Mine Platform, 2018).

In Sweden, 88% of EEE was collected and reported from the waste generated in 2010, as compared to 68% collected and reported in 2015 (Urban Mine Platform, 2018). With one of the highest rates of WEEE collection in the EU, in 2017 14.1kg of WEEE was collected per inhabitant in Sweden, as compared to the lowest rate of collection of 2.4 kg per inhabitant in Romania (Eurostat, 2021). Figures from Eurostat (2020) show that from 2015 to 2018, approximately 11% more EEE products were put on the Swedish market, even though the same time period shows that the rate of WEEE collected in Sweden had increased by less than 0.3%. Some explanations for these figures can be hypothesized, ranging from complexities in WEEE management, to delayed disposal patterns of consumers or long product lifetimes, however the case of WEEE management in Sweden is not simple.

Policy measures have been taken to address WEEE in Sweden, including tax reliefs for repair, public procurement of remanufactured EEE and government support of private re-use operations (Dalhammar et al., 2020). However, Sweden has been falling short of its WEEE directive obligations, with continuing issues regarding waste treatment permits, the responsibilities of waste holders and the assessment of hazardous waste (European Commission, 2019).

To combat the challenge of WEEE in Sweden there is a need for a greater understanding of the Swedish context, and to meet the government's ambitions for a CE WEEE is a crucial issue to address. The thesis study will address this problem by examining how we can elevate repair activities for electronics in Sweden as a societal effort towards a circular economy.

1.2 Problem definition

1.2.1 The areas related to the topic that other researchers have indicated are problematic

As explained above, in Sweden and around the world WEEE is a significant challenge. With unsustainable resource use and consumption, it is an urgent challenge as well. In Sweden, it is a key issue.

The EU Waste Framework Directive outlines principles for sustainable waste management and explains a model called the "waste hierarchy" (Figure 1-1 below) that has since been adopted into EU waste management legislation. In the Directive, Prevention is prioritized over Reuse which is over Recycling which is over Recovery, with Disposal as a last resort (European Commission, 2021; Swedish Environmental Protection Agency, 2009).
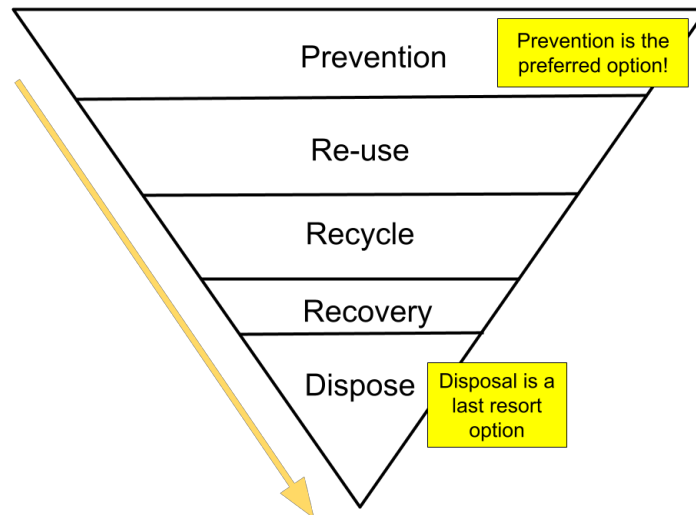
Figure 1-1: The waste hierarchy, Adapted from (European Commission, 2021)

A thesis pre-study that I conducted explored the topic of upscaling WEEE repair activities for a circular economy in Sweden with the aim of developing research questions for MSc thesis study. In the literature review conducted in that pre-study, I found important and relevant deficiencies in the existing body of work. With an additional small practitioner study, I tested that knowledge gap by analysing Sweden's new circular economy strategy and ultimately developed the research questions I am pursuing in this thesis.

The waste hierarchy is the foundation of waste management in the EU, establishing the order in which waste should be managed (European Commission, 2021). In the pre-study I found that research has shown that despite the law legislating this priority structure, in practice the recycling of electronics in Sweden has taken precedence over repair in the Swedish WEEE system. This represents an underutilization of viable electronics that could have an extended or second lifespan but are instead cut short. This happens as a result of exceptions that are needed in order to accommodate technical, financial or environmental factors (Avfall Sverige, 2018). Stated plainly by the EC (2010), waste management policies at the EU level aim to turn the region into a recycling society. Still, today, the EC favors recycling, stating that new waste proposals aim to meet increasing targets to recycle and reduce landfilling, thus "strengthening the application of the waste hierarchy" (European Commission, 2020).

Despite iterations of the EU WEEE Directive addressing the complex WEEE stream, recycling dominates as the preferred management strategy (Cole et al., 2019). Recycling is the standard method of processing WEEE because it is a low cost way of meeting current compliance standards (Cole et al., 2019). The disruption of the hierarchy through policy measures undermines the long-term goal of achieving a more circular society. It instigates a sub-optimal utilisation of resources by forgoing the opportunities to increase product longevity, repair and reuse (Cole et al., 2019).

The existing research also shows that there are more barriers to repair as compared to barriers against recycling in Sweden. Some of the barriers to repairing EEE included high logistics and specialized-labor costs, lack of access to spare parts, tight sales margins, obsolescence, data concerns, and anti-repair cultural norms (Albergotti, 2020; Almén et al., 2020; Cole et al., 2019; K. A. Whalen et al., 2018). The few barriers to recycling WEEE included destructive technology yielding low recovered materials, considerable GHG emissions and trace high-value materials

not being economically viable to recover (Albergotti, 2020; Almén et al., 2020; Cole et al., 2019; K. A. Whalen et al., 2018). What this balance of barriers shows is that there are still considerably more hurdles facing repair. Concerns range from economic (costs, margins, competition) to social (norms, data, brand image) and more. Beyond the policy measures incentivizing recycling, the barriers outlined indicate other intersecting forces play a hand in maintaining the systems of recycling despite the contradiction to the waste hierarchy model those systems maintain.

A review of the existing literature has also revealed that knowledge pertaining to which actors benefit from the choices to repair or recycle, and how, was scant. Among what knowledge that was found, Cole et al. (2019) stated that actors who operated at lower levels of the waste hierarchy still felt that they were reducing environmental impact. Salvage metals and plastics, the comparatively cheaper cost of recycling usable goods, and the easier and cost-effective transport of goods for recycling were also among the drivers for actors to pursue recycling over repair. This lack of a discussion around what construes benefits around repair or recycling, who experiences them and how, warrants further research. This persistent knowledge gap presents an opportunity for thesis research that can contribute to addressing it.

By addressing this knowledge gap, it is my goal that this research can help policy practitioners (such as the Ministry of Environment) and academics understand the Swedish WEEE problem and mobilise better initiatives that can work to make a difference in this area. It is important to not underutilize resources and it is important to dismantle systems that entrench unsustainable practices. Whilst we may have invested in a system of recycling viable electronics, we need to course correct and elevate repair. Exploring how we can elevate repair has benefits and impact, as this knowledge will allow initiatives like the Swedish Circular economy strategy to be better grounded by what is happening in reality.

1.2.2 The perspectives other researchers have used to study the problem

In order to place the research I am undertaking the context of the existing body of knowledge; I will briefly outline the perspectives some of the academic research I have encountered in this field have taken. In the pre-study literature review and in the initial literature review for the thesis, I found that it was not possible to find a research at the exact intersection of upscaling electronics repair for a circular economy and the actors-benefits dynamic involved in electronics repair/recycling. The papers I found were tangentially related to the problem area. This can support my assertion that this is an understudied intersection, or rather that it is at the forefront in a clear way. Of the papers that I did find, the following was noted regarding the perspectives or concepts other the researchers were exploring to conduct their studies.

Cole et al. (2019) assessed the achievements of the WEEE Directive in the UK by examining the barriers to applying the waste hierarchy to e-waste and how in practice recycling takes precedence over reuse in the EEE value chain. The key concepts invoked by the authors are circular economy, waste hierarchy, producer responsibility, reduce, reuse and recycle (Cole et al., 2019). Whalen et al. (2018) explore the barriers and potential for scaling reuse of ICT in Sweden. In their research, they explore the concepts of circular economy, circular business models, third-party 'gap exploiter' actors, and the idea of policy presenting barriers and opportunity for said gap-exploiters in ICT (K. A. Whalen et al., 2018). Dalhammar and Richter (2020) explored the right to repair electronics movement in Sweden. Some of the concepts that arise are circular economy, product repair, barriers to repair, policy intervention and right-to-repair legislation. Dewberry et al. (2016) explore the landscape of repair by examining the role of repair in creating new sustainable business models, how the concept of 'broken' affects repair activities, and how understanding how people relate to products can improve our understanding

of consumption. The concepts introduced by the authors are circular economy, sustainable consumption, drivers of efficiency and sufficiency, and product repair (Dewberry et al., 2016).

1.3 Aim and Research questions

The aims of this thesis research are to develop an understanding of the WEEE system in Sweden in practice, to explore what benefits actors in the Swedish system reap from choices to repair or recycle WEEE, and to gain an understanding of which actors receive those benefits from repairing or recycling WEEE in Sweden. It is the intention of this study that this knowledge embedded in the wider theme of sustainable development is used by the Swedish Ministry of the Environment (with whom I am collaborating with) to further efforts to achieve a circular economy in Sweden.

The three research questions (RQs) the thesis will explore are presented and justified below:

1. *How does the Swedish WEEE system function in practice?*

RQ1 is a line of enquiry into the "how", the "qualities or condition" of the Swedish WEEE system in practice. RQ1 builds on the research conducted in a pre-study conducted during the Applied Research course. This pre-study explored preliminary research questions (PRQs). PRQ1 asked "PRQ1: How does the Swedish WEEE system function in theory?". By exploring RQ1, the foundational knowledge on the Swedish WEEE system in theory and practice will be completed, allowing context for the closer examinations RQ2 and RQ3 necessitate.

2. *What benefits do actors in WEEE gain from participating in repair of WEEE vs recycling it?*

RQ2 is a line of enquiry into the "what", the "specificities and determination" of what benefits WEEE actors gain from participating in repair as contrasted with recycling. RQ2 builds on PRQ2 that asked "PRQ2: How can the benefits of the Swedish waste system be assessed?". Having explored how benefits can be assessed, through RQ2 I now seek to determine which benefits actors are receiving from repair vs recycle.

3. *What actors benefit from choices to repair vs recycle WEEE in Sweden?*

RQ3 is a line of enquiry into the "what", the "specificities and determination" of what actors are benefiting from the choices to repair or recycle WEEE in Sweden. RQ3 is built on PRQ3 that had tested and confirmed a knowledge gap, PRQ3 asked: "PRQ3: What is the current knowledge on the benefits from the choices to repair or recycle, as well as the actors who receive those benefits, in Sweden?". By asking RQ3, I now seek to determine which actors are benefiting from repair vs recycle. Through RQ2 and RQ3, the ambition is that this thesis research will contribute to addressing this knowledge gap around "what actors-which benefits" in repair vs recycle of WEEE.

It is anticipated that due to the iterative nature of the research process, these research questions will be re-developed and honed further throughout the course of the second literature review in the thesis research process.

1.4 Scope and Delimitations

My research intended to study a specific **focus**, namely the Swedish WEEE system and actors involved in WEEE management in Sweden – meaning organisations, companies, municipal bodies, and other such actors who perform work related to repair or recycling of WEEE in Sweden. My research focus was on actors that were actively involved in Sweden's WEEE

system, which includes recyclers, refurbishers, retailers, waste management, academic researchers, PROs etc. The number of interview respondents I interviewed was 6 experts. The number of online audio-visual materials I collected was 10, with a total of 28 experts featured in them.

In terms of **temporal** considerations, web-materials in the past 2 years were collected from actors' presence on the internet (which includes company websites, or other video hosting services as applied). This meant I could collect web-materials published earlier than my own thesis research period. I also attended one of the webinars as it occurred during the thesis research period. My interviews were conducted during the thesis period by contacting experts identified through their work in the Swedish WEEE system over the past several years.

Geographically, the research focused on the **nation state of Sweden**, whilst referring to the **wider European context where appropriate**. This consideration is done in light of Sweden's status as an EU member, which has implications for a multitude of national matters, including CE strategy and sustainable waste management.

There are methodological implications of my scope. By focusing on the system in Sweden today and in the recent past, there were methods of data collection and analysis that could help me understand the research problem. Online web-materials and semi-structured zoom interviews were judged to be appropriate methods of data collection given the scope I had delineated for my research. With web-materials, I was able to collect data publicly provided by actors, allowing me to analyse their own words and viewpoints. I was also, however, relying on information recorded and distributed by actors and possibly missing information that is not given this treatment. I am also relying to what could be considered self-reported data by these actors, not much unlike press material, given their materials were not collected in service of my research but their own agendas. By using semi-structured interviews conducted over Zoom, I am also perhaps missing additional or sensitive information that might have been shared more easily in a face-to-face interaction. My geographical, temporal, and topical scope also had implications for my method of data analysis. The methods of data analysis were primarily chosen to complement the two methods of data collection. The synthesis matrix method allowed me to draw out themes from the various collected materials. In doing so, the synthesized thematic findings are grounded the materials I collected. This method of data analysis was chosen to complement the methods of collection, and so I selected a method of analysis that could synthesise written notes without requiring direct transcription. The content analysis of interviewer notes allowed me to tease out further thematic findings from my collected data. In doing so, I ensured that I could draw out as much as I could from my materials. This method was chosen because it is a systematic way to analyse text. In choosing to apply the method to my interviewer notes, I avoided the labor of full transcription but may have forgone the details that could have been visible if I analysed full interview transcripts. The implication is that through the initial scoping decisions that eventually resulted in my choices to use the methods of a synthesis matrix and content analysis, I was able to unearth interesting findings whilst being frugal with the time and effort spent on rote work. In turn, I may have forgone finer insights that more labor-intensive methods of data analysis, for example content analysis of full transcriptions, could have provided.

Specific choices I made have several implications for the outcome of my research. I chose to use semi-structured interviews and reviewing web-materials as my methods of data collection as these were accessible and feasible given the COVID-19 pandemic and my own research capacities. Whereas it is possible that other methods could have been more appropriate, the chosen methods of collection were ones I had previous experience in and could undertake in the current global pandemic climate. The choices to use synthesis matrixes and content analysis

for data analysis were balanced between (1) what was appropriate for the collected research materials, (1) what would allow me to triangulate findings from multiple rounds of analysis, and (3) my own needs as a researcher for analysis methods that were simple, efficient, but effective.

In my research I am considering the Swedish context and have made the choice to limit my study to interviewing experts who are primarily involved with the Swedish WEEE system, and where necessary the EU. I can concentrate on exploring the research gap in Sweden, by doing so providing answers to fill it. This Swedish scope focus also means that methodologically I am considering the research problem in a limited capacity. The research problem of upscaling electronics repair has fundamentally global dimensions and implications, for which the Swedish WEEE system is embedded inextricably. By limiting my geographical focus primarily to Sweden, and only when necessary, to the EU, I am limiting my exploration of that global dynamic. In turn, however, my work is generalizable to contexts most similar to the studied case – which can be reasonably assumed to be the other Nordic countries in the EU with similar systems of WEEE management. This is beneficial for actors in my audience in similar contexts who could make use of this research. However, as the external contexts being considered for comparison differ more and more from the Swedish case I am studying in my research, the generalizability of my findings to those external cases decreases.

1.5 Ethical considerations

1.5.1 Researcher honesty and personal integrity

Regarding researcher honesty and personal integrity, the research is tied to the Swedish Ministry of the Environment who is interested in the work and the resulting thesis research. The Ministry was consulted when I was developing the research topic. The Ministry has not been directly involved in the development of my study, allowing me as a researcher to fully explore the research as I saw fit without influence on my findings, analysis, or conclusions. No funding was provided by any party. The external interest from the Ministry might have, however, fostered internal expectations for favourable or sensational research findings. To preserve the integrity of the research, I engaged in self-reflection and internal checks using a research journal. I regularly consulted with my thesis supervisor for updates and for guidance when faced with particularly conflicting choices. Transparency regarding the significant research decisions made will allow the audience insight into the dynamics at hand. Lastly, the thesis document names any external organisations that were involved in the research process.

1.5.2 Ethical responsibilities to the subjects of research

Regarding ethical responsibilities to the subjects of research, as per the codes of ethics outlined by (Blaikie & Priest, 2019), it is paramount that interview participants are engaged by their own will and do not suffer any harm of any kind from involvement in the research process. To ensure this does not happen, interviewees will be briefed on the purpose of the interviews, how their data will be used, and will be given opportunities to make requests (such as anonymity) for how their data is handled. Permission will always be asked regarding interview recording or quoting interviewees. Recoding will not be done without participant express consent. It is also important to uphold the confidence of participants who share sensitive information that could compromise them outside the research study, for example if they are sharing negative opinions of the systems they work within. Interview participants will be anonymized, as will the company they are associated with. Any participants engaged at any stage of the research process shall be provided the researcher's contact information so that they may communicate their accommodations or requests to withdraw from the research.

1.5.3 Data management

As it pertains to empirical data management, collected empirical data and interview data is stored on the researcher's Lund University student Gmail Services and Microsoft OneDrive accounts (this includes OneDrive, Google Drive, Gmail, Sheets, and other such services tied directly to the researcher's accounts) as well as on the researcher's encrypted personal laptop. As a result of being stored on the researcher's laptop, data copies are also stored on the researcher's backup external hard drive as part of a local backup system.

The research design has been reviewed against the criteria for research requiring an ethics board review at Lund University and has been found to not require a statement from the ethics committee.

1.6 Audience

The intended audience of this thesis research are: (1) my peers and instructors from the Environmental Management and Policy Master's program, (2) the Swedish Ministry of the Environment, and (3) actors involved in electronics repair activities for a circular economy in Sweden (this being manufacturers, third sector organisations, small businesses, and other such actors).

1.7 Disposition

The **Introduction** presents the research problem and scope. **Literature review** presents the current body of knowledge in my research area. **Research design, materials and methods** presents the research design and methodology of my study. **Findings and Analysis** outlines the thematic findings of my research study and analyses them. In **Discussion** I interpret, comparatively analyse, and weight the salience and meaning of the research findings in the context of the existing body of knowledge. **Conclusions** summarises the answers to my research questions, reflections, and takeaways.

2 Literature Review

Before I present the current state of knowledge in my research area, I must make a note to explain my literature reviews. **Four literature reviews** were conducted in the process of this thesis research. Across these four literature reviews, a **total of 49 artifacts of significant importance** were reviewed (32 artifacts in the thesis study period and 16 artifacts in pre-study). This figure is not accounting for **numerous supplemental artifacts** that were referred to in a limited capacity.

Thesis pre-study:

1. A preliminary literature review <u>before</u> the thesis period (AR course).
2. A pre-study literature review <u>before</u> the thesis period (AR course).

During the thesis period:

3. A preliminary literature review <u>during</u> the thesis period (Thesis course).
4. The primary literature review <u>during</u> the thesis period (Thesis course).

#(1) and #(3) The Preliminary Literature reviews

Two preliminary literature reviews were done, one during the pre-study and one during the thesis period. These preliminary explorations gave a general understanding of the research topic. The findings of those two preliminary literature reviews informed the information presented in Chapter 1: "Introduction" of the thesis.

#(2) The Pre-study literature review

To explain the pre-study a bit further, the thesis pre-study was done in the foundational research course "Applied Research" (completed prior to the thesis research period). My pre-study also explored the same research problem of "upscaling WEEE repair activities for a circular economy in Sweden". The aim of the pre-study was to (1) develop an understanding of the WEEE system in Sweden, (2) to explore how benefits of the Swedish system can be assessed, (3) to gain an overview of what is known about the actors involved and the benefits they receive from choices to repair or recycle WEEE, and (4) to serve as a pre-study for MSc thesis research. The research questions that guided the literature review in the pre-study were:

<u>Pre-Study Research Question 1</u>: How does the Swedish WEEE system function **in theory**?

<u>Pre-Study Research Question 2</u>: How can the benefits of the Swedish waste system be **assessed**?

<u>Pre-Study Research Question 3</u>: What is the current knowledge on the **benefits** from the choices to repair or recycle, as well as the **actors** who receive those benefits, in Sweden?

The goal of the AR course was to develop research questions that can be studied in a thesis course. The pre-study involved a small practitioner research study, where I tested the knowledge gap I had found in the literature by doing content analysis of the new Circular Economy strategy "Circular economy: Strategy for the transition in Sweden" that was published by the Swedish Government in 2020. The research questions I am currently exploring in this thesis were

developed as a result of the literature review and practitioner research study done in the pre-study course.

The findings of the pre-study literature review are also incorporated here because they formed the foundations on which I have built my thesis research.

Note: The findings from the pre-study literature review are indicated by the following header format: *2.x.x (Pre-study) (Relevant research question) Title of thematic Finding.*

#(4) The Primary literature review

To explore the research gap, the research questions developed during my pre-study were used to examine existing literature and publications during the thesis period. The findings of the knowledge related to electronics repair in Sweden and relevant theories and concepts are also presented in this chapter. Following the presentation of existing knowledge in the literature review, a conceptual framework is presented, and the research questions are then re-formulated.

The primary literature review is a continuation of the pre-study literature review, as such the findings from both are presented in this chapter. In total, between both literature reviews artifacts were examined as part of a systematic review exploring the research problem. Both literature reviews were conducted using a synthesis matrix to systematically parse out the themes in the existing body of knowledge and search for answers to the research problem. An interdisciplinary approach was taken for the literature reviews by ensuring materials were sourced from a range of academic disciplines. Reliable sources that were identified for the literature review were government reports and websites, reports from international bodies and research institutions, and journal articles. One news media source was also covered for insight in recent topical developments. To source materials for the literature review, I relied on the online search engine Google Scholar, Lund University's online databases Lubcat and LubSearch, and recommendations from both my AR topic supervisor and my thesis supervisor. Search terms I used included phrases such as "circular economy", "Sweden", "waste management", "repair recycle", and "cellphone repair Sweden". Materials were deemed relevant to the literature review if they addressed partially or completely one or more of the research questions.

The literature review as a tool to explore existing knowledge was useful for disclosing new information and knowledge gaps in the topic area (University of Wisconsin, 2020).

Note: The findings from the primary literature review are indicated by the following header format: *2.x.x (Relevant research question) Title of thematic Finding.*

2.1 Current knowledge related to electronics repair in Sweden

2.1.1 (Pre-study) (RQ1) The Division of Responsibility for WEEE in Sweden

EEE in Sweden is subject to Extended Producer Responsibility under the current waste management practice. In Sweden, it is the responsibility of producers and distributors to collect and treat WEEE. The process in which this responsibility is allocated is shown in *Figure 2-1* below.
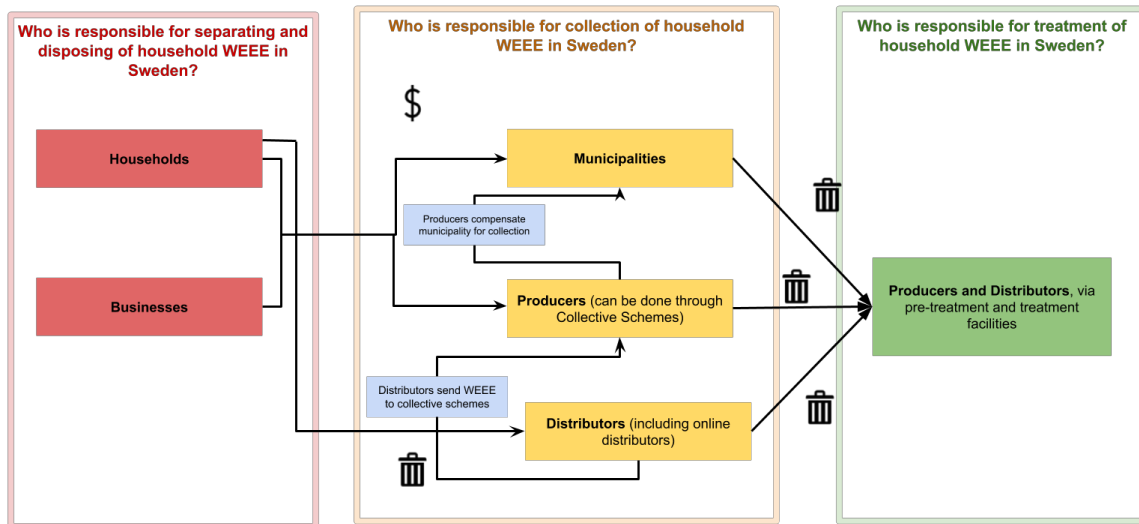
Figure 2-1: Responsibility for WEEE management in Sweden

Data Source: (Avfall Sverige, 2018; Swedish Environmental Protection Agency, 2020).

In Sweden, producers and distributors are accountable for the financial and organizational responsibility of managing household WEEE from households and businesses, which includes collecting and treating this waste (Avfall Sverige, 2018; Swedish Environmental Protection Agency, 2020). As shown in Figure 2 above, producers are responsible not only for caring for electronic goods (EEE) but also managing the resulting WEEE in the event of disposal (Swedish Environmental Protection Agency, 2020). If subject to EPR for household WEEE, producers can join collective schemes to manage this responsibility (Swedish Environmental Protection Agency, 2020). Where municipalities collect the household WEEE from residences or businesses, producers are required to compensate municipalities for the service and furthermore are responsible for the treatment of the waste (Avfall Sverige, 2018). Distributors are required to accept small WEEE from consumers without charge, and this collected waste is sent to the permit-holding collective schemes. Collected WEEE is sent to certified pre-treatment facilities for deconstruction, and then to treatment facilities where it can be recycled or given final treatment (Avfall Sverige, 2018).

2.1.2 (Pre-study) (RQ1) Recycling Is Prioritized Over Repair

Though prevention of waste is the priority for Sweden and the EU as per the waste hierarchy model, in practice exceptions to the rule are necessary in order to accommodate technical, financial or environmental factors (Avfall Sverige, 2018). Stated plainly by the EC (2010), waste management policies at the EU level aim to turn the region into a recycling society. Still, today, the EC favors recycling, stating that new waste proposals aim to meet increasing targets to recycle and reduce landfilling, thus "strengthening the application of the waste hierarchy" (European Commission, 2020).

Despite iterations of the EU WEEE Directive addressing the complex WEEE stream, recycling dominates as the preferred management strategy (Cole et al., 2019). Recycling is the standard method of processing WEEE because it is a low cost way of meeting current compliance standards (Cole et al., 2019). The disruption of the hierarchy through policy measures undermines the long-term goal of achieving a more circular society. It instigates a sub-optimal utilisation of resources by forgoing the opportunities to increase product longevity, repair and reuse (Cole et al., 2019).

The literature review revealed more barriers to repair as compared to barriers against recycling in Sweden. Some of the barriers to repairing EEE included high logistics and specialized-labor costs, lack of access to spare parts, tight sales margins, obsolescence, data concerns, and anti-repair cultural norms (Albergotti, 2020; Almén et al., 2020; Cole et al., 2019; K. A. Whalen et al., 2018). The few barriers to recycling WEEE included destructive technology yielding low recovered materials, considerable GHG emissions and trace high-value materials not being economically viable to recover (Albergotti, 2020; Almén et al., 2020; Cole et al., 2019; K. A. Whalen et al., 2018). What this balance of barriers shows is that there are still considerably more hurdles facing repair. Concerns range from economic (costs, margins, competition) to social (norms, data, brand image) and more. Beyond the policy measures incentivizing recycling, the barriers outlined indicate other intersecting forces play a hand in maintaining the systems of recycling despite the contradiction to the waste hierarchy model those systems maintain.

2.1.3 (Pre-study) (RQ3) Proposed Measures for Elevating Repair Over Recycling

To combat the aforementioned barriers to repair, some of the literature explores what can be done to elevate repair activities. Proposed measures include policy recommendations, such as raising the price of products and resources whilst reducing repair costs via labor and taxes, targeted policies that apply the waste hierarchy and policies to promote the purchase of expensive, high quality goods (Almén et al., 2020; Cole et al., 2019).

Policy measures are identified by Dalhammar and Richter (2020) and Cole et al. (2019) as the primary means through which an environment for repair can be fostered. This demonstrates the important role legislative bodies, particularly the Governments of Sweden and the EU, must play in upscaling repair activities. Furthermore, no single policy can address system failures, and well-designed policy combinations are best suited for driving transitions (Rogge et al., 2017). It will take a policy mix to elevate repair over recycling. The WEEE problem persists, however, meaning there remains room for the Swedish and EU governments to add more policy interventions to address the WEEE concern. This insight of government's role in WEEE through policy informed the choice made to examine the policy publication by the Swedish government as an artifact in the practitioner study.

2.1.4 (Pre-study) (RQ2) There Are Multiple Ways of Assessing Benefits

There are a myriad of assessment methods for assessing value in waste management and policy that focus on different domains of value, such economic, environmental, social or technical (Iacovidou, Velis, et al., 2017). In so doing, these single-dimension value metrics do not capture system complexity, obscure impacts and trade-offs, and conceal problem-shifting in the systems we develop to promote circularity (Iacovidou, Velis, et al., 2017). Some of the methods of assessing benefits in waste recovery that were examined in the literature review were CBA, CEA, intervention theory and CVORR. For the purposes of the pre-study, these methods were evaluated for potential application in the MSc thesis in determining benefits in Sweden's WEEE system.

CBA aims to indicate interventions with benefits larger than their costs (Mickwitz, 2006), whereas CEA measures the costs against the tangible effects resulting from the intervention (Görlach et al., 2005). As economic evaluation criteria, both utilise monetary figures to assist clear decision making and require decision makers to make explicit their assumptions (Mickwitz, 2006). However, economic approaches have difficulty valuing non-monetary effects, often rely on data availability, and evaluators must decide which costs to consider (Görlach et al., 2005; Mickwitz, 2006). Furthermore, through discounting, CBA devalues future costs and benefits (Iacovidou, Millward-Hopkins, et al., 2017).

Intervention theory is a model that makes explicit how a policy intervention is supposed to work (Mickwitz, 2006). In so doing, evaluators map the intended effects and target area of an intervention as well as clarify which outputs and outcomes require data collection (Mickwitz, 2006). With the intervention's logic made explicit, evaluation criteria such as the effectiveness evaluation criteria can determine how well the policy achieves its intended goals. A challenge, though, is the assumption that the right goals were being pursued by the policy to begin with. Furthermore, when it comes to assessing benefits in waste management, the effectiveness criterion is limited to the anticipated effects in the target area as it pertains to those goals (Mickwitz, 2006).

CVORR is a valuation framework that seeks to "assess how complex value is created, destroyed and distributed in resource recovery from waste systems" (Iacovidou, Millward-Hopkins, et al., 2017, p. 1280). It aims to combat the problem of single-domain metrics failing to address the complexity of value across multiple value-domains. Current assessment methods do not account for all value domains at the same time (Iacovidou, Velis, et al., 2017). However, in CVORR for example, one of the steps of the framework is assessing the political-legal framework waste systems operate in (Iacovidou, Millward-Hopkins, et al., 2017). If the benefits accrued by actors in the waste system are experienced across multiple value-domains, it follows that a technique that calculates and communicates those multi-dimensional outputs could aptly identify benefits and impacts relevant to stakeholders (Iacovidou, Millward-Hopkins, et al., 2017; Iacovidou, Velis, et al., 2017).

What remains to be noted when it comes to assessing benefits in waste management is *the impact problem*. It is difficult to determine which effects are due to any one policy instrument and which are due to other factors (Mickwitz, 2006). Part of selecting an appropriate benefit-assessment method for a singular waste management policy will be the capability to consider the impact of other policy instruments and external factors (Mickwitz, 2006).

There is potential for components of the CVORR method to be used in the thesis study to assess the actor-benefits knowledge gap. This understanding that value is complicated is a useful perspective. I consulted with my topic supervisor in the pre-study course on how I could assess benefits within the limited scope of the thesis study, as to do a full CVORR analysis is too large a task for a master's thesis. From her advice, taking elements of CVORR - namely **system mapping** or **value chain analysis** – would be sufficient for assessing who is receiving what benefits. **I have selected system mapping.** With this guidance and with the insight from the literature, I shall use my methods of data collection to ask and note down what experts say about the benefits and the actors. I will then use the information to compile diagrams summarizing who is receiving what benefits.

2.1.5 (Pre-study) (RQ2 & RQ3) There is a Persistent "Actors-Benefits" Knowledge Gap

The pre-study literature review revealed that knowledge pertaining to which actors benefit from the choices to repair or recycle, and how, was scant. Among what knowledge that was found, Cole et al. (2019) stated that actors who operated at lower levels of the waste hierarchy still felt that they were reducing environmental impact. Salvage metals and plastics, the comparatively cheaper cost of recycling usable goods, and the easier and cost-effective transport of goods for recycling were also among the drivers for actors to pursue recycling over repair.

This lack of a discussion around what construes benefits around repair or recycling, who experiences them and how, indicated an area ripe for future research.

2.1.6 (RQ1) The Swedish WEEE System Functions Well, But Has Challenges

Literature shows that the Swedish WEEE system, after two decades of operation, has delivered desirable outcomes, despite some lingering issues. In Europe, by collecting large volumes of waste Sweden's WEEE system has been the best performing since its initial launch (Hui Mien Lee & Sundin, 2012). In 2010, nearly 4 times the waste mandated by the WEEE Directive were collected by Sweden annually, approximately 15kg per capita (Hui Mien Lee & Sundin, 2012). A high electronics consumption rate and a general sense of common responsibility amongst stakeholders have predisposed the Swedish WEEE system to desirable outcomes (Hui Mien Lee & Sundin, 2012).

However, the system maintains some systemic and implementation issues. Some of the problems observed in the Swedish WEEE system are trickle down challenges, originating much higher up in the product's lifespan – such as design decisions, manufacturing and the like (Hui Mien Lee & Sundin, 2012). In this case, these kinds of troubles are passed down until they can bore down no further along the chain. There is a lack of incentives of stakeholders like big collection companies to push beyond the minimum required collection amounts. Stakeholders like El-kretsen can sideline environmental performance for economic gain, wherever the system could allow (Hui Mien Lee & Sundin, 2012). In addition, overall process friction such as excessive bureaucracy can decision insecurity amongst stakeholders u(Hui Mien Lee & Sundin, 2012).

Furthermore, barriers to repair on the consumer side inhibit progress that would otherwise be achieved. Where earlier we spoke of troubles inherited from earlier product life stages in the WEEE system, some of those problems come to bear as barriers to repair via three different ways. As Svensson et al. (2018) delineate, barriers can occur at three levels: (1) legal obstacles inhibiting repair accessibly, (2) costs of repair and other factors diminishing the economic viability of repair to consumers, (3) consumer culture against repair.

Sweden's approach to EPR has prioritized recycling, despite this representing an unnecessary underutilization and degradation of materials (Kunz et al., 2018). Despite iterations of the EU WEEE Directive addressing the complex WEEE stream, recycling dominates as the preferred management strategy (Cole et al., 2019). Recycling is the standard method of processing WEEE because it is a low cost way of meeting current compliance standards (Cole et al., 2019). The disruption of the hierarchy through policy measures undermines the long-term goal of achieving a more circular society. It instigates a sub-optimal utilisation of resources by forgoing the opportunities to increase product longevity, repair and reuse (Cole et al., 2019).

2.1.7 (RQ1) Cellphones are a particular electronics group of interest for repair

Cellphone repair is difficult and riddled with barriers, despite being a critical frontier to WEEE circularity. This issue mirrors parallel challenges found in other high value small consumer electronics like laptops. Whalen et al. (2018) find that reuse of electronic products is central to a circular economy, and by extension this includes the product lifetime extension of goods such as cellphones. Numerous barriers face cellphone repair, including retaining high resale value and managing escalating logistic costs (K. A. Whalen et al., 2018). Cellphones in particular are widespread, yet they are known for short product lifespans and their chronic technical and perceived obsolescence (Ongondo & Williams, 2011). This combines to create a condition where cellphones are of growing concern in WEEE management (Ongondo & Williams, 2011), underlying the urgency of addressing operations to extend product lifespan. Not least the concern with waste management, cellphones represent a key material issue (Ongondo &

Williams, 2011). This means then that metals and minerals are lost to the consumption cycle in a linear economy, whether or not the cellphone's lifespan was prematurely cut.

Whilst cellphones are materially valuable and might be repairable, it is still difficult to do so. Wieser and Tröger (2018) found that perceptions about cellphones rate of obsolescence is key for repair in Austria. Bovea et al. (2017) found that 9.6% of consumers take their EEE to be repaired. These findings indicate the tangible impact of the barriers to repair on repair ecosystems. Understanding then who is benefiting when repair is done, and what benefits they are accruing when they do so is key to unpacking how then to elevate repair.

2.1.8 (RQ1) A variety of actors are involved in the repair of cellphones in Sweden.

There is a network of different actors that stand to benefit from choices to repair cellphones in Sweden. Figure 2-2 has been developed below to summarise in brief the kinds of actors involved in the repair of cellphones in Sweden that were identified in literature.

Figure 2-2: The actors involved in the repair of cellphones in Sweden

Original Equipment Manufacturers and Producers

Refurbishment / Repair businesses (includes Small unauthorized repair businesses)

Consumers

Network service providers and Retailers

Second-hand sellers

Government

Data Source: (Rizos et al., 2019; Svensson et al., 2018; Svensson-Hoglund et al., 2020, p.; Watson et al., 2017), Vector Images are under Creative Commons

2.1.9 (RQ2) Actors participating in phone repair experience several benefits.

There is benefit to be had by the **producers** and **Original Equipment Manufacturers** (here to referred to as "producers") if they facilitate phone repair (Svensson et al., 2018). By getting ahead of this repair trend, companies are benefitting from the blue ocean advantages of pioneering and setting the standards of operation. By branching out business into repair services, producers can form partnerships, make deals with other companies to facilitate repair services and sell parts to authorized repairers (Watson et al., 2017). Establishing takeback schemes allows a leverage point through which producers can engage with the repair market to

their benefit. Furthermore, **network service providers**, who are closely situated to producers in the mobile phone value chain, can also engage these take back schemes (Watson et al., 2017). Lastly, producers can reap the benefit of lessening the environmental impact of new devices (Watson et al., 2017), allowing them to meet social and environmental responsibilities.

Network service providers, retailers and producers operate take back schemes, whilst **refurbishers** process and resell the take-back phones. Large refurbishing companies have been professionalised, as a result decreasing the skepticism they once faced on the market. (Watson et al., 2017). Network services providers benefit from selling their take-back phones to refurbishers and secondhand sellers because they can access a business opportunity to make money. By not directly doing the repairs and selling second hand, they avoid the high costs of refurbishing (due to high labor costs in the Nordics) and relatively low selling price of used phones. Furthermore, small businesses can also scrape out a viable business operation for themselves by taking on that challenging high cost – low sell price environment. (Watson et al., 2017)

Takeback schemes will provide the devices that **refurbishers** can in turn process and resell (Watson et al., 2017). By engaging in established systems of repair, refurbishers can enjoy professionalization thus increasing consumer confidence in second hand devices (Watson et al., 2017). Such businesses structured around servicing old phones benefit from the repair movement, as they are reporting a rapid growth in demand (Watson et al., 2017).

Consumers who purchase secondhand phones are not primarily motivated by the environmental benefits of reducing waste, but rather find primary benefit in the cost savings of purchasing refurbished phones (Watson et al., 2017). Even though consumers don't care about the environment as much as the money savings, producers see value in reducing the environmental impact of new devices (Watson et al., 2017).

When it comes to small unauthorized repair shops, a prolific growth in **small unauthorised repairers** offering repair services, used phones and accessories exists in the Nordics. They threaten the producers, who respond by limiting access to parts and writing strict warranty terms. The small unauthorised repairers respond in turn by using low quality parts. The big companies benefit by limiting the professionalization of small repair operations (who don't live up to environmental and social responsibilities), whilst ensuring the professionalization of their own operations. This however disadvantages smaller businesses who might want to offer good quality repair services. (Watson et al., 2017)

There are also **secondhand sellers** can benefit from new businesses given the increased demand in secondhand phones from consumers (Rizos et al., 2019).

2.1.10   (RQ2) The benefits actors experience from participating in phone repair can be problematic or conflicting

Following a Danish court case about the legality of providing a cellphone with refurbished parts as a replacement for a faulty device, Watson et al. (2017) predict that in the Nordics as a whole, fixing faulty phones with refurbished parts might be disincentivized by a legal system that penalized repairers for doing so. This shows that the legal system needs to support repair activities, otherwise this and peripheral repair operations might feel at risk if other parts of society do not incentivise repair and refurbishing phones. Though this occurred in Denmark, it is still of importance to Sweden as a fellow Nordic and EU country.

In addition, Watson et al. (2017) outline how repair operations selling secondhand phones might be held to the same guarantees as sellers of new phones under the Consumer Sales Directive.

What this means is that secondhand sellers might benefit from increased consumer confidence in secondhand phones, but they might also be disadvantaged by the increased costs of repair from raising quality assurance standards and checks (Watson et al., 2017).

In line with the market incentives OEMs have to discourage repair, Svensson et al (2018) find that the repair of devices is in direct opposition to the profits from sales of new devices. In a way then some of the benefits experienced by consumers and manufacturers compete and can be mutually exclusive. As a result, Svensson et al (Svensson et al., 2018) find that balancing the interests of both actors and public interest is key to minimizing waste and preserving resources.

Finally, Watson et al. (Watson et al., 2017) find that Nordic countries persist in exporting second hand phones for reselling to developing countries, despite a second-hand market being established in the Nordic region. This is an offloading of the eventual waste management responsibility into systems less equipped to manage WEEE flow. Refurbishment and export companies could be required to participate in a form of EPR by managing proper waste disposal in the developing countries (Watson et al., 2017).

2.1.11 (RQ3) Economic tools can be leveraged to incentivize actors into greener practices

In France, economic tools are being leveraged to encourage producers in EPR system to engage in eco-design. Such an approach could be adopted in Sweden to encourage producers to engage in another green practice, repair. Micheaux and Aggeri (2021) describe how eco-modulation, or the practice of modulating product fees based on the extent of their eco-design, pushes EPR systems towards providing incentives for producers to eco-design. What this case shows is that in Europe producers can be given monetary incentives for engaging in green practices, like repair. It also demonstrates the role EPR systems play in enabling practices or nudging new ones.

When producers join PROs, they are able to fulfil their legal obligations under the WEEE directive whilst also benefiting economies of scale by joining a collective plan (Micheaux & Aggeri, 2021).

2.1.12 (RQ3) Actors in the phone repair business experience some disadvantages because of the nature of their work

Research shows actors in the repair ecosystem can encounter difficulties or obstacles. Firstly, actors can encounter competition from other businesses positioning themselves to also take advantage of the repair market (Watson et al., 2017). Expensive labor is needed to run repair operations, and regional conditions in the Nordics make the business of repair quite expensive to a level worth noting and thus possibly unlike other regions of the world (Watson et al., 2017). Furthermore, some of these disadvantages might originate from preceding stages of the value chain. Researchers in Spain found that in order to allow repair at a later stage of an electronic device's life, the devices have to be well-made first and the design of the device must facilitate repair (Pereira et al., 2020). In addition, the Spanish researchers Pereira et al. (2020) found more obstacles to repair:

- They found that access to and the high costs of spare parts is an obstacle in the repair business – to the extent that purchasing a new device entirely could be more economical.
- They found that an absence of repair information in the form of guides and manuals means repairers don't have the information they need.
- Because repair is so difficult, they found the number of service providers in the repair market has declined.

- They found that with the increase of globalization forces, such as production centralization in Asian countries, the cost of producing EEE has declined to the extent of lowering product prices.
- They summarised that overall electronic devices on the market devices are now more fragile, yet hard to fix without excessive force.

What the researchers discovered in Spain is unfortunately similar to what has been observed of the repair market in the EU/Sweden. Other researchers who have studied the EU/Swedish repair market have found similar phenomenon. As covered in Chapter 1, section 1.2.1 the barriers to repairing EEE several researchers noted included high logistics and specialized-labor costs, lack of access to spare parts, tight sales margins, obsolescence, data concerns, and anti-repair cultural norms (Albergotti, 2020; Almén et al., 2020; Cole et al., 2019; K. A. Whalen et al., 2018).

2.1.13 (RQ3) Actors in the repair ecosystem do not experience equivalent rewards

Actors who engage in repair do not all experience the same benefits from doing so. Watson et al. (2017) show a break down the mobile phone producers, retailers of new phones, network service providers and how they are engaging in mobile phone repair. Of the reported motivations for engaging in repairing phones, 60% of the motivation for actors comes from economic value, 15% comes from CSR value and 25% is other (Watson et al., 2017). These three rewards actors get from engaging in phone repair are summarized in Table 2-1 further below. As shown, not all three groups experience the same rewards from repairing phones.

Network services providers benefit from selling their take-back phones to refurbishers and secondhand sellers because they can access a business opportunity to make money. By not directly doing the repairs and selling second hand, they avoid the high costs of refurbishing (due to high labor costs in the Nordics) and relatively low selling price of used phones.

Table 2-1. 3 actor groups and what they gain from repairing phones

Mobile phone providers	Retailers	Network service providers
Fulfil customer demands	Fulfil business initiatives by taking back used phones	Retain current customers and attract new customers
Address low WEEE collection rates	Attract customers	Ensure consumer loyalty
Economic value from takeback schemes	Repair as part of profitable business model	Economic value from selling fixed phones to new users or refurbishers
CSR value from takeback schemes	Fulfil high demand for repair services	Control the fate of repaired devices to diminish competition in local market from international actors

Data Source: (Watson et al., 2017)

Watson et al. (2017, p. 35) write that "the majority are engaging because they can see a direct business opportunity for raising revenue, for example by selling or repairing phones". Watson

et al. (2017) also state that small businesses can create a viable operation by taking on that challenge of high cost to repair/low selling price of repaired phones.

2.2 Critical review of literature

The existing body of literature in this research area is limited. Across the four literature reviews, I reviewed a total of 49 artifacts. Naturally, with a limited number of relevant articles and documents the pool of knowledge I am drawing in my research from is smaller. It is important for me to note that the thematic findings I have drawn in this literature review are from a field of research with a small number of relevant studies.

Of the works that I reviewed, I noted some key takeaways that I will take into consideration as I develop my research design:

- Wieser and Tröger (2018) used **semi-structured interviews** in their methodology. I am strongly considering this method of data collection as well.
- Bovea et al (2017) conducted a **stakeholder identification process** to find the actor they wanted to survey. They did this by searching databases. I will modify this approach and consider utilizing web-searches to find actors relevant to Sweden's WEEE system.
- As proposed by Iacovidou, Millward-Hopkins, et al. (2017), **complex value** is a concept I should consider carrying forward as I develop my research design. I shall structure my methods of collection and analysis to try and capture as many domains value as I can.

2.3 Key theories and concepts

Below is a brief overview of some important concepts and theories related to the research problem. These are concepts that also came up during the four literature reviews, indicating their relevance to the research problem.

Circular economy is a concept that concerns eliminating waste, reducing resource consumption, and increasing system resilience by slowing (promoting reuse), narrowing (reducing material consumption) and closing (end-of-life recycling) material loops (Iacovidou, Millward-Hopkins, et al., 2017; IIIEE, 2019). Slowing loops remains the most challenging and important measure as it necessitates a change in product design, manufacture and end-consumer use (IIIEE, 2019). As a result, repair, refurbishment and remanufacturing play a key role in product lifespan extension by allowing goods to be kept in material loops for longer (Bakker et al., 2014). The three "loop" principles of the circular economy guide our understanding of which practices can be considered environmentally friendly and to what degree. As such, this concept is crucial when exploring phone repair in Sweden's WEEE system.

Shown in Figure 1-1 earlier, the **waste management hierarchy** is a conceptual model for waste management that prioritises waste prevention, reuse, and recycling over recovery or disposal (Pires & Martinho, 2019). After some years of incorporation in member states via the Waste Framework Directive in 2008, the model was present in the EU CE Strategy 2015 as a strategy for the best environmental scenario and material management (Pires & Martinho, 2019). What we do know though, is that despite being adopted into EU WEEE policy the waste hierarchy has been disrupted – "recycling is the primary end-of-life process for electrical and electronic equipment despite waste prevention and reuse being higher in the hierarchy" (Cole et al., 2019, p. 7). By using this understanding of how WEEE treatment methods should be prioritized, I can identify when actors are treating WEEE in a manner that aligns with circularity principles.

The concept of **complex value** as outlined by Iacovidou, Millward-Hopkins, et al. (2017, p. 1280) proposes that value exists across multiple value domains. This matters for waste management as actors can benefit in multiple ways from their role in the WEEE system. The concept was introduced in the discussion regarding the CVORR valuation framework as a method for assessing benefits and the actors that receive them. Observing value from only one domain (whether environmental, economic, social or technical) inhibits decision makers from understanding the reality of system complexity, impacts or trade-offs inherent to systems that promote circular economy (Iacovidou, Velis, et al., 2017).

Intervention theory as outlined by Mickwitz (2006) is a model that breaks down how a policy intervention is supposed to work. The theory comes from the field of environmental policy analysis. As stated earlier, by using this theory, evaluators map the intended effects and target area of an intervention as well as clarify which outputs and outcomes require data collection (Mickwitz, 2006). Chen et al. (1997) demonstrated the usefulness of intervention theory when they explored the outcomes of a garbage reduction program in Taiwan. By mapping the logic of the policy instrument, they could identify when it had worked and when it had failed. Crucially, the approach helped them understand why failures and successes had occurred in the garbage reduction program. Mickwitz (2003, p. 424) explains that intervention theories are used in policy evaluation because (1) 'they can be used to establish the intended effects of the instruments and the target area of each instrument" and (2) "they can be used to determine which outputs, outcomes and causal links to collect data on". Taking this approach in my research, it is my anticipation that by laying out how the Swedish WEEE system functions in theory and in practice, I gain better understanding of how it is supposed to work and how it actually works. It will also help me see the discrepancies between the Swedish WEEE policy in theory and the Swedish WEEE policy as it is executed in practice.

These theories and concepts will be used to guide my research questions and overall research design.

2.4 Revised research questions and research aim

Following the literature review, I find it necessary to adjust my research questions to better explore the research gap I have found. Modifications are emphasised with **bold** text. The three research questions (RQs) the thesis will explore are presented and justified below:

4. *How does the Swedish WEEE system function in practice **when it comes to cellphones?***

RQ1 is a line of enquiry into the "how", the "qualities or condition" of the Swedish WEEE system in practice, specifically when it comes to cellphones. RQ1 builds on the research conducted in the pre-study and the multiple literature reviews. By exploring RQ1, the foundational knowledge of how the Swedish WEEE system works in theory and practice when it comes to cellphones will be completed, allowing context for the closer examinations RQ2 and RQ3 necessitate.

The literature review showed that cellphones are a unique electronics group in Sweden's WEEE system. It is worth examining how they specifically are treated in that system.

5. *What benefits do actors in WEEE gain from participating in the **repair of cellphones vs the recycling of cellphones?***

RQ2 is a line of enquiry into the "what", the "specificities and determination" of what benefits WEEE actors gain from participating in the repair as contrasted with the recycling of

cellphones. Having explored how benefits can be assessed in the pre-study, through RQ2 I now seek to determine which benefits actors are receiving from repair vs recycle of cellphones.

The literature review showed that there is a knowledge gap regarding the benefits actors get when they repair or recycle cellphones. It is worth examining how cellphones specifically are treated in the Swedish system.

6. *What actors benefit from choices to* **repair cellphones vs recycle those cellphones in Sweden?**

RQ3 is a line of enquiry into the "what", the "specificities and determination" of what actors are benefiting from the choices to repair or recycle cellphones in Sweden. RQ3 is built on PRQ3 that had tested and confirmed a knowledge gap, PRQ3 asked: "PRQ3: What is the current knowledge on the benefits from the choices to repair or recycle, as well as the actors who receive those benefits, in Sweden?". By asking RQ3, I now seek to determine which actors are benefiting from repair vs recycle of cellphones. Through RQ2 and RQ3, the ambition is that this thesis research will contribute to addressing this knowledge gap around "what actors-which benefits" in repair vs recycle of cellphones.

The literature review showed that there is a knowledge gap regarding which actors are benefiting from choices to repair or recycle cellphones in Sweden. It is worth examining how they specifically are treated in that system.

With the revised questions, the research aim of my thesis also evolves. My updated research aim is to develop an understanding of the WEEE system in Sweden in practice when it comes to cellphones, to explore what benefits actors in the Swedish system reap from choices to repair or recycle cellphones, and to gain an understanding of which actors receive those benefits from repairing or recycling cellphones in Sweden.

3 Research Design, Materials and Methods

3.1 Research design

Table 3-1 and Figure 3-1 have been used to summarise how the research design will address each research question. As shown in Table 3-1 below, the underlying research philosophy of the author is stated, preceding and underlying the overall aim of the research. It is from this aim that the three research questions were initially developed. Following the literature review, the three research questions were revised – it is these revised research questions that are shown in Figure 3-1 and referred to from this point on. In Figure 3-1 it is visually indicated how each line of inquiry (these lines of research inquiry are named Stream 1 and Stream 2) corresponds with the research questions, demonstrating a cohesion in the methods chosen. In further sections, justifications for each of the chosen methods are given.

Table 3-1. Research philosophy and Research aim

Ontological position: **Idealist** Epistemological position: **Constructionism**
Research aim: The aim of this thesis research is to develop an understanding of the WEEE system in Sweden in practice when it comes to cellphones, to explore what benefits actors in the Swedish system reap from choices to repair or recycle cellphones, and to gain an understanding of which actors receive those benefits from repairing or recycling cellphones in Sweden. It is the intention of this study that this knowledge (embedded in the wider theme of sustainable development) is used by the Swedish Ministry of the Environment (with whom I am collaborating with) to further efforts to achieve a circular economy in Sweden.

Figure 3-1. Research Design & Methods of Data Collection and Analysis
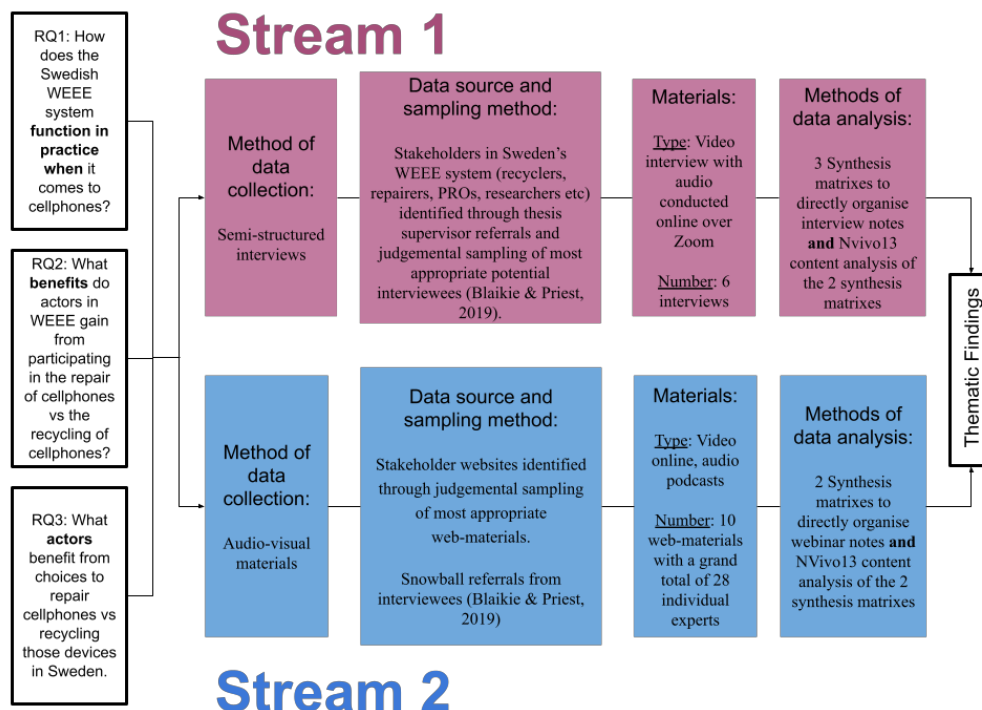
A **qualitative methodology** has been selected for the research design, as it is best suited to a research problem that will be difficult to quantify but could be explored qualitatively. Qualitative research is fundamentally interpretive (Creswell, 2003), meaning that my interpretation as a researcher is engrained in the findings. As a researcher I am a black African woman, raised in multiple cultures, studying a Master's in Environmental Management and Policy at a large university in Sweden. The findings will be filtered through my view of what is significant, and it will be paramount that I make my research process decisions clear. It stands to say that other qualitative researchers might come to different interpretations of the same research problem and materials.

3.2 Methods used to collect data and critique

The **semi-structured interview** method was selected because it has the advantage of allowing the researcher to deeply engage participants' knowledge but through fairly controlled questioning information can be gathered (Creswell, 2014). As an **alternative** method, a structured interview could have been appropriate as well, given more pre-interview research. This primary source of data involved 6 interviews with WEEE stakeholders running for 30 minutes that were conducted via the online video calling application Zoom. Expert individuals were identified beforehand for interviewing, making the gathered information more salient and efficient to collect. My thesis supervisor assisted me in identifying potential interviewees. As the interviews progressed, snowball referrals were requested from interviewees in order to find more potential interviewees in this field. As such, two sampling methods for data selection were used determining the pool of potential interviewees – judgemental sampling to identify initial interviewees and snowball referrals from interviewees (Blaikie & Priest, 2019). In this way, I could take advantage of sourcing interviewees from highly relevant stakeholder groups and also asking them to refer me other relevant individuals; though the disadvantage of creating my pool of interviewees in this way are that I am relying on my interviewees having strong professional networks and assuming my researcher judgement in selecting appropriate initial interviewees was accurate (Blaikie & Priest, 2019).

A drawback with this method of data collection is that the information collected through this method is coloured by the perspectives of the interviewees and the quality of the information relies on the eloquence of the interviewee (Creswell, 2014). In addition, the recording and notetaking during the interviews might have also affect participants' responses.

An **interview protocol** (see Appendix 1) was developed that identified potential interviewees, their contact information, their work title and company, as well as justification of why they were of interest. My potential interviewees were identified during the literature review and in discussions with my supervisor. As interviews carried on, interviewees were also asked for expert referrals I could interview as well. My interview protocol was also used to keep track of any interviewees referred to by other previous interviewees. The protocol included details of procedural steps for before, during and after the interview – which included (for example) consent for recording and for quotations being obtained from each participant. The protocol also included the interview questions that were brainstormed and developed from the research questions. Multiple versions of the protocol and interview questions were developed, culminating in a final refined protocol that was appropriate for the research problem. Four sets of interview questions slightly tailored to each type of WEEE stakeholder were developed: (1) PROs, (2) Refurbishers/Repairers/Remanufacturers, (4) Recyclers, and (3) Researchers. This was done to maximise the amount of valuable information from each expert group. The goal in having interview questions directly drawn from the research questions was so that each question I would be asking my interviewees would be building answers to the research questions. The final protocol was reviewed and approved by my thesis supervisor prior to the interviews being conducted. A uniform procedure was utilised to reach out to potential interviewees, specifically

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an email template that was customised with the details of each recipient. Similarly, a uniform follow-up email was pre-written to send to each participant following interview. The development of a protocol allowed each interview to be approached with as much uniformity and professionalism as possible. The interview protocol also allowed me to keep track of my interviews, my interviewees, and my data.

As this stage as I critically evaluate this method of data collection, it is very important to discuss the impact induced by the **COVID-19 pandemic** on the interview method, specifically that interviews that could have been conducted face-to-face were instead conducted online via Zoom. There was an ease allowed there, as interviewees from remote distances could be reached easily. In addition, the video calls were recorded (if participant consented), allowing me to listen back and clarify notes were needed. However, this tool also meant that interviewees had to be available via the internet and willing to have a lengthy video interview. Research has shown that "Zoom fatigue" is a problematic phenomenon arising from the use of video-calling to uphold social distancing. Zoom fatigue is a type of exhaustion that arises as the result of prolonged videoconferencing (Bailenson, 2021). All my interviews were conducted over Zoom, as such this tool had an effect on the data collected during my interviews. A significant part of inter-personal communication is non-verbal, namely timed vocalisations, gestures and movements that allow conversationalists to determine if the other party is understanding them clearly (Bailenson, 2021; Wiederhold, 2020). Without these in-person cues and with the technical delays inherent to video calling, we expend more mental energy and performance trying to stay in sync with the other person, making online communication exhausting (Wiederhold, 2020). We are also cut off from the body language we use to see if the other person understands us, given that video calls only frame the face (Wiederhold, 2020). It is therefore important to note that mental exhaustion in the participant was a key consideration. To this end, the target length of interviews was limited to 30 minutes such that the effects of exhaustion could be avoided. To avoid the effects of miscommunication, participants could elaborate on their own answers through the semi-structured format; and the interview questions were written to clarify and build on each other. In addition, using the techniques proposed by Bailenson (2021) and Wiederhold (2020) to combat Zoom fatigue, the framing of the video was so that my face was fully lit to allow the participant to see my micro-expressions, I ensured that my non-verbal cues and active-listening vocalisations were obvious, I mounted my webcam to allow a horizontal line of sight with my eye-level, and I ensured my head and shoulders dominated the frame.

As shown in Table 1, the semi-structured interview is used to address all three research questions by utilising access to expert interviewees to directly respond to the research questions. Interview questions will be based on the research questions, therefore the knowledge from the experts will directly respond to the research questions.

Audio-visual materials (specifically online webinars, online conferences, and podcasts) were also used to source data (Creswell, 2014). For these "web-materials", I took on a 'complete observer' role, meaning I observed in the web-materials without participating (Creswell, 2014). The reliable secondary sources that were identified for the web-materials were stakeholder websites. I attended one of the online webinars as an audience participant by invitation from one of my interviewees. For the other web-materials, search terms used on Google's video search engine were phrases such as "circular economy webinar Sweden", "Sweden WEEE webinar", "waste management Sweden webinar" and "repair recycle cellphones Sweden webinar". Web-materials from relevant stakeholders were then selected.

The web-materials were identified as appropriate if they fulfilled the following **criteria** shown in Table 3-2 below. This criteria approach is grounded in a method of data selection known as "judgmental sampling", a data selection approach as described by Blaikie and Priest (2019)

where a researcher uses their knowledge of the research problem to identify the most appropriate sources of data. The advantage and disadvantage of this sampling method for this type of data collection is that while I could use the research I had done to efficiency identify which stakeholders were knowledgeable of my research problem, I also had to accept the risk that my knowledge and research could be limited and not capture all the appropriate stakeholders for my research problem.

Table 3-2. Criteria for webinar selection

Criteria for web-material selection	Determining if web-material can be used	
1. Is the web-material **hosted or made available by a stakeholder** relevant to Sweden's WEEE system?	If **Yes**, web-material can be used	If **No**, web-material cannot be used
2. Is the web-material attended to by **expert panelists** who are stakeholders in the Swedish WEEE system?	If **Yes**, web-material can be used	If **No**, web-material cannot be used
3. Was the web-material published within the **past 2 years**?	If **Yes**, web-material can be used	If **No**, web-material cannot be used
4. Is a **full video or audio** available to the public online and for free?	If **Yes**, web-material can be used	If **No**, web-material cannot be used

This method of data collection had advantages and disadvantages. The advantages of the audio-visual materials method are that the method is unobtrusive and allows me to listen directly to how stakeholders phrase their own experiences and knowledge (Creswell, 2014). The disadvantages of the method are that the most useful or relevant materials might not be available publicly or privately, may be difficult to understand, and the method itself is time consuming (Blaikie & Priest, 2019; Creswell, 2014). By opting to use only web-materials that fulfil my criteria as listed in Table 3-2, I have also excluded materials that do not fulfil those criteria but could have otherwise divulged unique insights. Where my selection criteria provided and a systematic procedure structure, they also limited the range of materials I considered. In light of this point regarding the advantages and disadvantages to the audio-visual materials method, an alternative method could have been **documents** in the form of reports and publications from WEEE stakeholders (Creswell, 2014). The advantages of that alternative method would have been the ability to analyse the unobstructed and direct words of the stakeholders, to save the effort of transcribing or note taking, and convenience (Creswell, 2014). The disadvantages would have included searching these documents out (which from my pre-study course I know is difficult), the possibility of incomplete documents, and the labor involved in reading through long reports (Creswell, 2014).

There is also what I termed an overall "agenda-effect" with these specific data materials. As a secondary source of data, these web-materials were not conducted for the benefit of my research. But rather each web-material serves the agenda of its host, colouring the information shared. It is also important to know that the web-materials were not designed to serve my research questions, and as such my engagement with the materials was listening to the web-materials and taking only the transcriptions and notes relevant to my research. Where these web-materials are a way for stakeholders to discuss openly about issues in the field, they are also

imbued with the curated public image of their host. It is reasonable to assume these materials would not share highly controversial information or leave a negative impression of the web-material host company on the audience, and so these materials have already been filtered through the agenda of the web-material host. I utilize triangulation to counteract the overall "agenda-effect" in this method by means of (1) using the same questions raised in interviews in my analysis matrix for the web-materials, (2) using multiple sources, and (3) overall using multiple methods to inform my research (Blaikie & Priest, 2019, p. 215). Therefore, by receiving multiple answers to the same questions from various data sources and methods, it is my hope that triangulation can diminish some of these disadvantages to the audio-visual materials method of data collection.

3.3 Materials collected

Table 3-3 below lists the materials collected in my research, as well as details regarding each artifact. **6 semi-structured interviews** were conducted, and **10 web-materials** were reviewed (6 webinars, 2 conferences, and 2 podcast episodes). One of the webinars, Webinar A, I attended as an audience member.

Table 3-3. Collected materials

Method of data collection	# of artifacts	List of interviewees and expert panelists
Semi-structured interviews via Zoom	A total of **6 interviewees**	• **Int. "Association",** a CEO and Managing Director from a Swedish Waste Management and Recycling Association. • **Int. "Waste-to-Energy",** a CEO from a Swedish waste-to-energy company. • **Int. "PRO",** a Vice President of Business Development at a Swedish PRO. • **Int. "Recycler",** a Business Specialist at a Swedish Recycling Company. • **Int. "Researcher 1",** a Researcher in extended producer responsibility and Swedish WEEE policy at a Swedish industrial environmental economics Research Institute. • **Int. "Researcher 2",** a Project Manager at a Swedish environmental Research Institute.
Web-materials (webinars, conferences, and podcasts)	**6 online webinars** with a total count of **17 expert panelists** *(Note: the total count here is 18 experts, but one expert spoke at two webinars and so is*	**Webinar A** on "Circular electronics – Towards 100% Reuse" (1h duration) hosted by Inrego, a Swedish global IT refurbisher. I attended as an audience member in April 2021 by invitation of one of my interviewees. Panel consisted of 4 experts: • **Henrik Lampa,** a Head of Sustainability at Dustin (a Swedish IT retailer) • **Sara Nordbrand,** a Head of Sustainability at Telia (a Swedish IT retailer) • **Alexandra Wu,** a Project Manager at IVL (a Swedish Environmental Research Institute)

counted only once). **2 conferences** accessed via recordings posted online with a total count of **12 expert panelists**. **2 podcast episodes** published online with a total of **3 expert guests**. In total, 32 experts are featured in the web-materials. However, some of these experts feature in more than one material. When this is accounted for, **a grand total of 28 individual experts are featured in the web-materials**.	• **Sebastian Holmström,** a Circular Strategy Lead at Inrego (a Swedish global IT refurbisher) **Webinar B** on "Adapting to the 2021 European right to repair initiative for electrical and electronic products" (1h 10min duration) hosted by HQTS, a Chinese international supply chain management company. Published April 2021. Panel consisted of 4 experts: • **Ernestas Oldyrevas,** a Program Manager at Environmental Coalition on Standards (an international NGO advocating environmentally conscious technical standards, policy, and laws) • **Ugo Vallauri**, a Co-founder and Policy Lead at The Restart Project (a British charity and community-driven social enterprise facilitating electronics repair) • **Robert Alexander**, a CEO at EEESafe and at LocalitEEE (a British organisation facilitating electronics repair and a second organisation that is a cloud-based sustainable living community) • **Damien Smith**, a CEO at Ecodesk (an international company that helps businesses around the world with ESG strategy) **Webinar C** on "Circular Economy and the Effects on our Industry"(25min duration) hosted by Inrego, a Swedish global IT refurbisher. Published March 2021. Panel consisted of 2 experts: • **Christoffer Sandell,** a CEO of Inrego (a Swedish global IT refurbisher) • **Sebastian Holmström**, a Circular Strategy Lead of Inrego (a Swedish global IT refurbisher) **Webinar D** on "Five approaches to circular electronics" (55min duration) hosted by TCO, a Swedish global sustainable IT certification company. Published December 2020. Panel consisted of 5 experts, 4 of which were relevant: • **Kristina Liljestrand,** Researcher and Project Manager in Supply chains, Food logistics, Climate Impact and Food waste at Chalmers Industriteknik (a Swedish consultancy) • **Sebastian Holmström,** a Circular Strategy Lead at Inrego (a Swedish global IT refurbisher) • **Joost de Kluijver,** a Founder and CEO at Closing the Loop (a European e-waste compensation company working with circular procurement of IT in Europe) • **Johan Brändström**, a PhD researcher in circular economy and support at 3stepIT (a Finnish company that works in sustainable IT lifecycle management) **Webinar E** on "Another four approaches to circular electronics" (1h duration) hosted by TCO, a Swedish global sustainable IT

certification company. Published February 2021. Panel consisted of 4 experts, only 3 of which had available footage:

- **Steve Haskew,** a Head of Sustainability and Social inclusion at Circular Computing (a British Laptop remanufacturer company)
- **Annette Karlberg,** a Marketplace Director Generalist at Blocket (a Swedish online marketplace company)
- **Joel Lindquist,** a Project Manager Sustainability at ATEA (a Nordic IT infrastructure company)

Webinar F on "The Material Sector's first Steps towards a Circular Economy" (1h) hosted by The German-Swedish Chamber of Commerce. Published November 2020. Panel consisted of 5 experts; however relevant portion of webinar featured 1 expert:

- **Ibrahim Baylan**, the Swedish Minister for Business, Industry, and Innovation.

Conference A titled "Session 7b – Circular Treatment of Reused Electronics and E-waste" (1h 30min) hosted by Chalmers University of Technology, a Swedish university. Accessed online. Published April 2021. Panel consisted of 6 experts:

- **Pascal Leroy,** Director General of the WEEE Forum (a multi-national, non-profit association focused on WEEE management)
- **Joost de Kluijver,** Founder and CEO of Closing the Loop (a European e-waste compensation company working with circular procurement of IT in Europe)
- **Kristina Liljestrand,** Researcher and Project Manager in Supply chains, Food logistics, Climate Impact and Food waste at Chalmers Industriteknik (a Swedish consultancy)
- **Fredrik Benson,** Vice President of Business Development at El-Kretsen (a Swedish PRO)
- **John Baxter,** Senior Researcher at NORSUS (a Norwegian sustainability research institute)
- **Burçak Ebin,** Researcher in Chemistry & Chemical Engineering and Industrial Materials Recycling at Chalmers University of Technology (a Swedish University)

Conference B titled " Minimised waste and maximise use: A deep dig into circular economy" hosted by Chalmers University of Technology, a Swedish university. Accessed online. Published November 2019. Panel consisted of 7 experts, of which 6 experts were relevant:

- **Eva Ahlner**, a Senior Advisor at the Swedish Environmental Protection Agency

		Leonardo Rosado, an Associate professor in Water Environment Technology at Chalmers University of Technology (a Swedish university) **Maria Ljunggren Söderman**, an Associate Professor in Environmental Systems Analysis at Chalmers University of Technology (a Swedish university) **Árni Halldórsson**, a Professor in Supply Chain Management at Chalmers University of Technology (a Swedish university) **Björn Johansson**, a Professor in Production Systems at Chalmers University of Technology (a Swedish university) **Mélanie Despeisse**, an Assistant Professor in Production Systems at Chalmers University of Technology (a Swedish university) **Podcast A**, an episode titled "Circular Economy 101 with Katie Whalen" of the podcast *The EarthyB Podcast*. Published October 2019. Guest consisted of 1 expert: **Katie Whalen**, a PhD researcher in circular economy and circular business at the IIIEE (a Swedish Research Institute) **Podcast B**, an episode titled "Recycle of re-use? De wereld van circulaire IT" of the podcast *Impact Podcast*. Published December 2020. Guests consisted of 2 experts: **Christoffer Sandell**, a CEO of Inrego (a Swedish global IT refurbisher) **Sebastian Holmström**, a Circular Strategy Lead of Inrego (a Swedish global IT refurbisher)

How I conducted my interviews is described in more detail under section 1.2 "Methods used to collect data and critique". In summary, an interview protocol was used to find my interviewees, develop research questions, and conduct the entire interview process. My 6 interviews were conducted over Zoom and they had a duration of 30 minutes, though some of them ran over time. Four sets of interview questions with 40 questions total between them were developed for each stakeholder group as explained in section 1.2. Some of these questions repeated between the 4 sets, some questions were multi-part questions, and some questions were follow-up questions. During some of the interviews I took notes directly into my synthesis matrixes. The synthesis matrixes contained questions from the interview protocol to ensure that (1) I was gathering only information relevant to my research questions, (2) to allow triangulation of my data and (3) to organise the interviewee's responses in a meaningful way. For some of the interviews where I was not taking notes (as this was a technique I developed later to save time), I listened to the recordings in my own time and took notes. The focus of my interviews was to use my interview questions to collect answers that could address the research questions.

How I conducted my web-material review is described in more detail under section 1.2 "Methods used to collect data and critique". In summary, I reviewed web-materials I found online. I searched for web-materials online via Google's video search engine and attended one

of the webinars by invitation of one of my interviewees. I used transcriptions of the web-materials to input into my synthesis matrixes. As with the interviews, the synthesis matrixes contained questions from the interview protocol to ensure that (1) I was gathering only information relevant to my research questions, (2) to allow triangulation of my data and (3) to organise the information I was receiving in a meaningful way. The focus of my web-material method was to use information from the web-materials to address the research questions as much as relevant and was possible.

3.4   Methods used to process information and critique

A data analysis framework was developed to process the information I had collected. Figure 3-2 below shows the overview perspective to the methods of data collection and analysis, the *Research Methods Procedure*. Within the figure you can also see the *Data Analysis Framework*. The data analysis framework is comprised of Steps 2 to 4 in my research procedure, where Step 1 is data collection. The data analysis framework uses **a synthesis matrix** and **software-supported content analysis** methods. The data analysis framework is shown in detail in a separate figure, in Figure 3-3, further below.

Figure 3-2. Research Methods Procedure: An overview of the methods of data collection and methods of data analysis
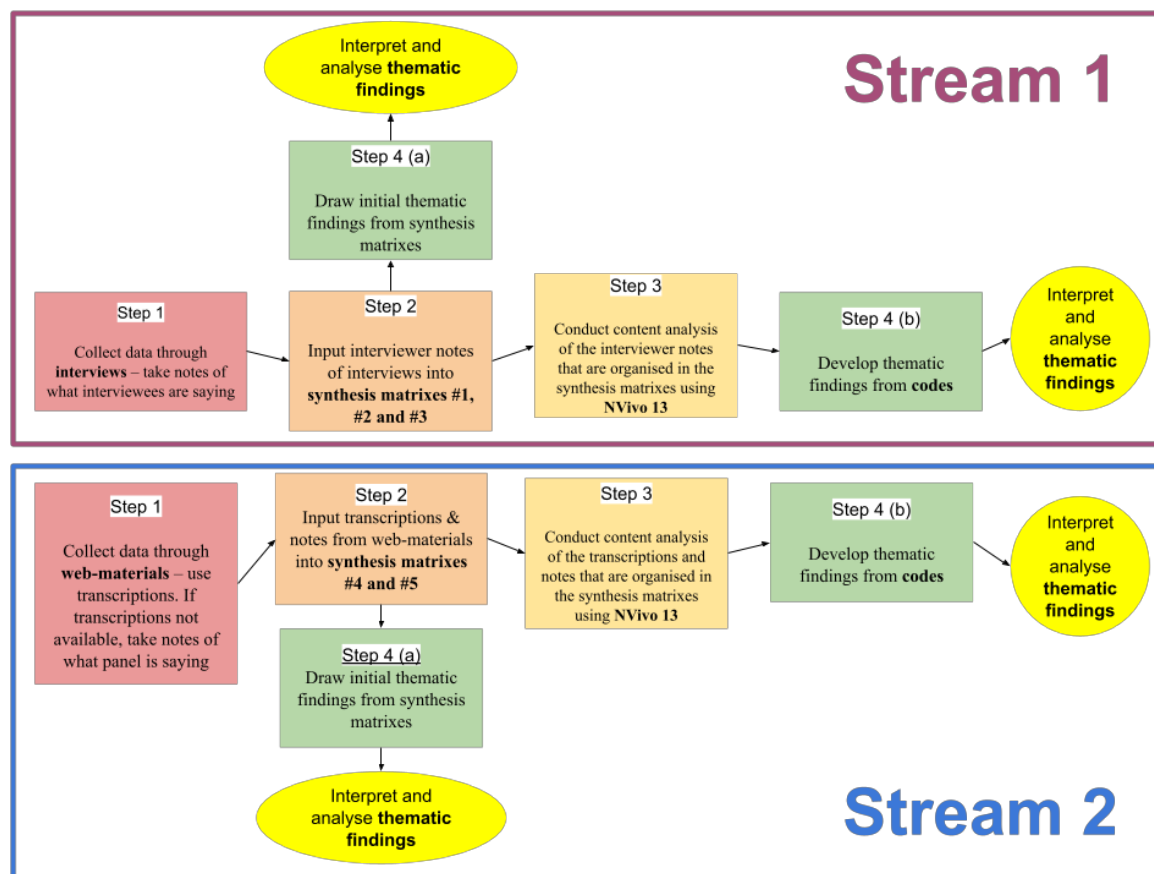
To describe the image above, the first part of my research procedure is shown by Step 1 where I collect the data materials. Data analysis begins at Step 2. Step 2 involved organizing these materials into 5 different synthesis matrixes. Within the matrixes, it was possible to draw out some initial thematic findings, as shown by Step 4(a). With further processing occurring in Step 3, I conducted content analysis of both my interviewer notes and the transcriptions (both which

were already organised in the 5 synthesis matrixes). I used software to assist in this process. Step 4(b) involved developing some thematic findings from the tagged codes.

The **synthesis matrix** tool (see Appendix 3 for sample) was used to systematically parse out the themes in the data and address the research questions. The matrix tool allowed me to sort and categorize the various pieces of information I had collected (Ingram et al., 2006). I created 5 synthesis matrixes. The five synthesis matrixes were filled with the data (transcriptions and notes) gathered from my interviews and web-materials. I only entered data that was relevant to the Swedish WEEE system and answered my research questions. The lines of inquiry in the synthesis matrixes were developed from my interview questions for each group.

1. **Matrix 1:** Interviews – PRO
2. **Matrix 2:** Interviews – R4 (Refurbishers/Repairers/Remanufacturers and Recyclers)
3. **Matrix 3:** Interviews – Researchers and other Stakeholders
4. **Matrix 4:** Web-materials – Refurbishers/Repairers/Remanufacturers and Recyclers
5. **Matrix 5:** Web-materials – Researchers and other Stakeholders

Once the matrixes were complete, thematic findings could be drawn out from the organised information. The method does have some drawbacks. By using the interviewer notes from my interviews and not direct transcriptions, I was analysing text that had already been pre-filtered through my own comprehension and did not directly come from the interviewee. Though my notes of what the interviewees were saying are my best representation of the interviewees' words, they are not as representative as direct transcriptions. The benefit of conducting this analysis on my notes of what the interviewee was saying however, is that I could save much time and labor involved in transcribing with a reasonable expectation that my notes are aligned with the interviewees' responses. In contract, by using transcriptions of 9 out of 10 of my web-materials, I could analyse experts' own words directly. The webinars were quite long and information heavy, so the transcriptions saved me labor whilst allowing me to analyse experts' own words. Here, I benefited from the computer-generated transcriptions created from the online content.

Content analysis was chosen to analyse the data further, and this was done digitally using the qualitative data analysis software NVivo 1.3.1 from QSR International. I turned the 5 synthesis matrixes into PDF files. Then in NVivo13, the synthesis matrixes were analysed. Creswell (2014) provides a linear, bottom-up approach to "Data analysis in qualitative research" (2014, p. 196) and this approach was taken into consideration during the content analysis. I also utilized "The Spiral of Analysis integrated into the qualitative research process" as described by (Boeije, 2010, p. 90). Figure 3-3 below is an adapted image that depicts in detail my *Data Analysis Framework*, as informed by Boeije (2010) and Creswell (2014). Content analysis was chosen as it is a systematic analysis that provides insight into complex communication, though a significant drawback is that it was a time consuming technique (Columbia Public Health, 2019). Conducting the content analysis on my interviewer notes also faced the same advantages and drawbacks as I detail in the paragraph above in my discussion of the synthesis matrix tool.

For the interviews, interviewer notes were taken and analysed. I had the permission of 5 out of the 6 interviewees to record the interviews, allowing me to review my notes for accuracy if needed. For 9 of the web-materials, full transcriptions of the materials were analysed. For 1 of the web-materials (Webinar A that I attended), researcher notes were taken and analysed.

The step-wise approach to data analysis as detailed by Creswell (2014, p. 196) and the Spiral of Analysis detailed by Boeije (2010) were my inspiration in developing my own multi-step data analysis framework that contains within it well-established methods of data processing.

Alternative approach to qualitative data analysis that could have been adopted is for instance "Tesch's Eight Steps in the coding process" from Creswell (2014, p. 198). Though quite similar to the processes I used as described by Creswell (2014) and Boeije (2010), Tesch's process to coding differs when it comes to the details of the steps it requires the researcher to complete.

Figure 3-3. Data analysis framework, adapted from (Boeije, 2010, p. 90; Creswell, 2014, p. 196)
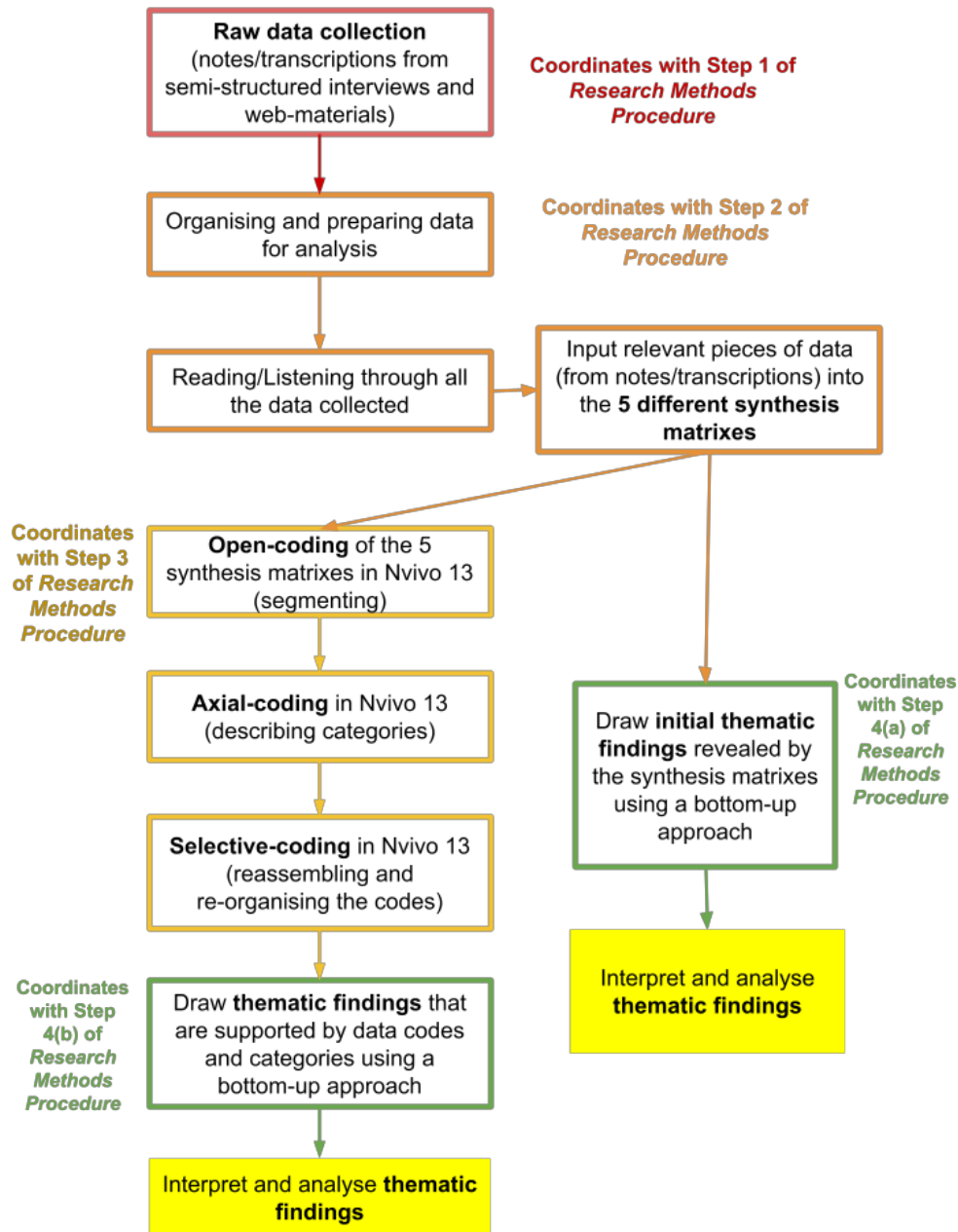
3.5 COVID-19

The impact of COVID-19 is described in detail to the method it affected the most in my research experience, the interviews. Please refer to section 3.2 "Methods used to collect data and critique". As for my audio-visual materials method, it was also likely due to social-distancing from the pandemic that several of the web-materials from 2020 and 2021 were recorded and readily available online. In a normal time, many of the webinars/conferences could have been conducted in person and otherwise harder to access for me as a student researcher.

4 Findings and Analysis

My findings and analysis are presented below in an **intertwined** fashion. There are 11 thematic findings. I also have chosen to organise my findings **thematically**, rather than organising them according to the Stream of research inquiry (in brief, rather than organizing them as "findings from interviews" and "findings from web-materials"). I find this approach limits repetition and allows me to highlight the most interesting insights.

Note: For each thematic finding, the format is as follows: **4.x (Coordinating research question):** *Thematic finding in a brief sentence.* The header is then followed by <u>diagrams</u> or <u>tables</u> or <u>NVivo13 treemaps</u> highlighting core findings and then <u>analytical text</u>.

Note: Interviewees are anonymized using the following citation format: ***Int. "One word descriptor", Description of job title and company, personal communication, date***.

Note: The full NVivo13 codebook with code descriptions is available in Appendix 2.

4.1 (RQ1) There are many actors involved in Sweden's WEEE system when it comes to phones, some of them are obscure

Figure 4-1: The actors involved in Sweden's WEEE system for Thematic Finding 4.1

<u>Data Sources:</u> (Holmström, 2020, 2021b; Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021; Sandell, 2020). Vector images are under Creative Commons.

Figure 4-1 above summarised the actors involved in Sweden's WEEE system. Below, the roles of these actors are described in a list:

1. **EU and SE government**: The EU develops EU-level legislation on waste management, circular economy, right-to-repair, and EU-wide take-back schemes. The SE government implements legislation for waste management in Sweden and recently developed a new national circular economy strategy. The Swedish Environmental Protection Agency monitors the WEEE collection system. (Baylan, 2020; Holmström, 2021b; Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021)

2. **Researchers**: Collaborate with PROs to provide information and knowledge about electronic products. Consultancies help actors with research and tracking metrics. (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Lampa, 2021)

3. **Associations**: Associations for municipalities are municipal-owned and represent them in the area of waste management. (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021)

4. **Repairers and Refurbishers**: There are levels of repair, consumer repair and commercial repair. Commercial refurbishers refurbish electronics by buying, fixing, and selling them. Small repair shops also harvest parts. (Holmström, 2021c; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021)

5. **Municipalities**: Collect WEEE that is not part of the EPR. Municipalities also cooperate with producers to organise collection system for WEEE in Sweden. (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021)

6. **Consumers**: Dispose of devices or provide the supply repair-viable devices. (Sandell, 2020)

7. **Network Service Providers and Retailers**: These two actors are the main sellers of phones of various models in Sweden. Network service providers also do most of the collection and are an intermediary between producers and consumers. Retailers sell hardware and subscription services. Retailers also provide on-site collection points for phones. (Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Lampa, 2021; Nordbrand, 2021)

8. **Producer Responsibility Organisations (PROs):** PROs provide collection points where other actors can gather goods to recondition and sell on the market (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)

9. **Storage companies**: Store old devices for business consumers. (Holmström, 2020; Lindquist, 2021)

10. **Producers**: Under the WEEE Directive, producers organise the collection system for WEEE in Sweden. They also design, manufacture and conduct repairs on the devices they make. (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Sandell, 2020)

11. **Waste-treatment companies**: Facilitate collection of devices on site (Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)

12. **Transporters**: Take collected devices to pre-treatment plants (Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)

13. **Pre-treatment companies**: These are big actors in Sweden, the biggest of which is "Recycler" is associated with one of my anonymized interviewees Int. "Recycler". In this capacity, "Recycler" harvests electronics for components. This actor also provides spare parts. (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)

14. **Recyclers**: Retrieve metals and precious metals from e-waste to sell in batches to refineries. (Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)

15. **Refineries**: Extract types of metal from circuit boards. Some companies own mines and refineries in Europe. (Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)

What these role descriptions and Figure 4-1 show is that many actors are involved in Sweden's WEEE system. Some are more directly obvious, like the municipalities, recyclers, and government. However, other actors were more obscure in my data, such as storage companies and researchers. For Sweden's WEEE system to function well, these actors (and perhaps many others that were not captured by my data) must coordinate and work well together. As Int. "Waste-to-Energy" explained, (personal communication, May 12, 2021) there are a bunch of different actors working together. With this level of participation across public and private society, the complexity of ensuring functional WEEE management in Sweden can be appreciated. This leads into the following sub-thematic finding, that role evolution is critical to actors remaining viable and functional in the SE WEEE system. Four of these actors are discussed.

4.1.1 (RQ1) Role evolution is critical to WEEE actors remaining viable

As shown in Figure 4-2 further below, various actors are experiencing role evolution in order to remain viable in the Swedish WEEE system. My data above revealed producers, PROs, recyclers, and retailers as some of those actors.

As shown above for **producers**, the five ways they are evolving indicate rapid transformation and adaptation to shifting consumer demands. They are transforming their business models by offering services that promote repair and changing how they think about repair. Smartphones are too valuable for them to ignore repair, so much so that it can justify the costs of facilitating repair (Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021). Producers hold a significant amount of power because the data showed that shifting their business models to allow repair (through product design for repair, providing spare parts, competitive repair pricing, etc.) would allow other actors to also do more repair than before. If they continue to resist consumer push for repair however, the data showed that legislation could successfully push for system transformation.

For **PROs**, the data most significantly showed that they must act outside their legal roles to remain economically competitive and socially acceptable. As Int. "PRO" stated, (personal communication, April 26, 2021) "To do just what the law is telling us to fulfil, that would be a road to a slow but certain death. You have to evolve." The PRO role must change towards repair if we are to achieve a circular economy, which also implies the law (e.g., PRO recycling targets) must evolve as well. Int. "PRO" (personal communication, April 26, 2021) confirmed this logic during interviewing. They reinforced the sentiment that the PRO role must evolve by noting that current legislation is for devices that were circulating 25 years ago. Quite importantly, Int. "Association" (personal communication, May 12, 2021) emphasized that in order for PROs to be incentivized to evolve towards repair, legislation needs to make repair

and reuse mandatory. Thus, in the data we see that role evolution is critical to actors remaining viable, even if that creates incongruencies with current law.

Figure 4-2: Role evolution of some actors involved in Sweden's WEEE system for Thematic Finding 4.1.1

Role evolution of Producers in Sweden's WEEE system
- Producers are changing business models to facilitate repair and offer services that promote repair.
- If major phone producers engage in repair and make it economically viable, the system would transform. This would also happen if legislators make it law.
- Producers are shifting mentality towards supporting repair.
- Producers are being pushed to design for repair.
- Phones are prolific and very valuable, and producers could recapture value from one product.

Role evolution of PROs in Sweden's WEEE system
- PROs must prioritise circularity to avoid backlash from society.
- PROs can extract salvageable components and parts.
- PROs are collaborating with researchers and provide product information and knowledge.
- For PROs to work with repair, legislation needs to make it mandatory.
- PROs need to make repair economically viable, just as they evolved away from exclusively relying on metal values years ago.

Role evolution of Recyclers in Sweden's WEEE system
- Recyclers are engaging in repair and reuse.
- Recyclers have difficulty connecting to repair business opportunities.
- Recyclers can change agreements with PROs to allow repair where appropriate.
- Recyclers need technical expertise and equipment for repair.
- Recyclers can contract other actors to repair.

Role evolution of Retailers in Sweden's WEEE system
- Retailers are collaborating with refurbishers.
- Retailers are changing business models by offering services that promote repair.
- Retailers are introducing sales targets for reuse, selling reused phones and other services.
- Communication with consumers to normalise reused devices.

Data Sources: (Halldórsson, 2019; Holmström, 2020; Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021; Lampa, 2021; Nordbrand, 2021; Sandell, 2021; Vallauri, 2021; K. Whalen, 2020; Wu, 2021)

For **recyclers**, I will highlight that the data showed they can change the agreements they have with PROs to be more flexible. This would mean recyclers having the liberty to decide whether devices need to be recycled or repaired (Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021). Int. "Researcher 1" notes that such an arrangement would not disadvantage the PRO because repair and recycling count towards the same target. As with the PROs above, contractual obligations matter to the role recyclers are performing – to do something other than what's on paper would be to go against their obligations. Introducing flexibility and updating waste policy as it related to both actors is therefore crucial.

For **retailers**, similar to producers, expanding their business models to accommodate repair services is important. As a direct contact point with consumers, convenient repair services

would encourage consumers to repair the phones they value so highly. Collaborating with other actors to facilitate repair, in this instance refurbishers, also introduces the point that role evolution can occur not only within an actor group but also in the relationships between actor groups.

4.2 (RQ1) There are several good features of the SE WEEE system that allow it to be successful when it comes to phones

Table 4-1 below highlights the 4 core findings that support Thematic Finding 4.2. Sources from which these core findings were drawn are also provided.

Table 4-1: Core findings from data analysis of interviews and web-materials for Thematic Finding 4.2

Core Finding	Corresponding data sources
A lot of used electronics are collected because SE consumers have a **strong culture** of sorting behavior and environmental consciousness *and* it is easy to get rid of waste.	(Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021)
Electronics producers **work together**, **help,** and **understand** each other, and created **one well-organised collection system** through the PRO El-Kretsen. This removes the troubles of **competing collection systems** and controls **illegal activity**.	(Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)
The SE WEEE system was designed to **involve** and be **accessible** to all actors *and* was introduced to a society that **already** had a waste system for electronics. Waste electronics management had been **legislated for a long time**, preceding the WEEE Directive.	(Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021; Leroy, 2021)
The SE WEEE system is **monitored by the Swedish EPA**, thus preventing free-riders and allowing PROs to do their job.	(Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021)

As shown in Table 4-1 above, a core finding was that **a lot of used electronics are collected because SE consumers have a strong culture of sorting behavior and environmental consciousness *and* it is easy to get rid of waste**. Swedes' strong environmental consciousness and behaviours meant that consumers (both private and commercial) were willing and capable of sorting waste properly. Other experts have noted this "green" culture in Sweden. Nordbrand (2021) states that as a major Swedish electronics retailer, Telia observes that customers are also willing to engage with sustainable WEEE management practices and services. It is Swedish

culture that the environment matters as explained by Int. "Recycler" (personal communication, April 22, 2021).

Furthermore, it is very easy to dispose of WEEE in Sweden, meaning consumers are not facing large obstacles in disposing their waste (personal communication, April 22, 2021). Such can be expected to happen, because **the Swedish WEEE system was designed to involve and be accessible to all actors *and* was introduced to a society that already had a waste system for electronics. Waste electronics management had been legislated for a long time, preceding the WEEE Directive.** The existing WEEE system was introduced to a society with a pre-existing system, and it has had time to develop and mature. Sweden's WEEE system was designed with the actors in mind. In fact, the first CEO of the PRO El-Kretsen was from a Swedish waste-to-energy company (Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021). That consumers in the system would be able to dispose of their WEEE smoothly is a result of a well-established and mature system.

Actors within this single collection system are also working together and establishing relationships that benefit the system. **Electronics producers work together, help, and understand each other, and created one well-organised collection system through the PRO El-Kretsen. This removes the troubles of competing collection systems and controls illegal activity.** As explained by Int. "Association", it is critically important that Sweden has only one collection system because that means there aren't multiple collection system competing with each other or triggering a race to the bottom (personal communication, May 12, 2021). This collaboration in the system can be leveraged to achieve greater outcomes than the sums of its parts, as shown in the statement by the Swedish retailer Telia that collaboration is key to making the shift to a circular economy (Nordbrand, 2021).

Sweden's WEEE system is also highly regulated. **The Swedish WEEE system is monitored by the Swedish EPA, thus preventing free-riders and allowing PROs to do their job.** This kind of visibility and "on the books" operation allows the system to function following law; because it is visible to see what it is that actors are doing with their WEEE. With a thoughtfully designed system that considers all relevant actors, good relationships between actors, and external monitoring by a government body; Sweden's WEEE system has very good features that has led to some good outcomes and collection rates over the years.

4.3 (RQ1) There are also several negative features of the SE WEEE system that either cause problems or limit success when it comes to phones

Table 4-2 below highlights the 6 core findings that support Thematic Finding 4.3. Sources from which these core findings were drawn are also provided.

Table 4-2: Core findings from data analysis of interviews and web-materials for Thematic Finding 4.3

Core Finding	Corresponding data sources
It is **actually too easy to dispose** of broken devices and **too expensive to repair** them. Linear consumption is therefore convenient as new products are also **cheaper**.	(Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Wu, 2021)

With **current technology for material recovery**, it's only economically viable to extract **limited range of materials** for recycling.	(Holmström, 2020; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021)
PROs **prioritise material recycling and new products** over repair as their **money comes from material recycling**. As a result, the WEEE system does too (for example collected **phones aren't handled carefully** because recycling is the assumed default treatment).	(Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021, p. 2)
Legislation (WEEE Directive) **prioritizes recycling over repair**. As a result, the WEEE system does too. Legislation needs to **evolve to include and support repair** meaningfully.	(Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Sandell, 2021; Wu, 2021)
Device hoarding and **pre-mature discarding** by consumers is limiting the stream of used devices critical to support repair activities. As a result, **there is a larger demand for reused devices than there is supply**.	(Holmström, 2020; Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021; Lindquist, 2021; Sandell, 2021)
Sweden's **WEEE system is still linear in some ways**.	(Holmström, 2020; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021; K. Whalen, 2020)

As shown in Table 4-2 above, a core finding was that **it is actually too easy to dispose of broken devices and too expensive to repair them. Linear consumption is therefore convenient as new products are also cheaper.** An unfortunate downside of a convenient collection system is that it can be readily mis-used. Int. "PRO" (personal communication, April 26, 2021) shared that it is so easy to get rid of e-waste and new phones are so cheap that it is the easy choice for consumers to not bother with repair. Consumer behaviours like what I term "**device hoarding" and pre-mature discarding are limiting the stream of used devices critical to support repair activities. As a result, there is a larger demand for reused devices than there is supply.** Sandell (2021), the CEO of Inrego (a large Swedish global IT refurbisher that also works with phones) shared that they have a great demand from consumers but they don't have enough items to supply as not all units are being reused. Inrego is actually sourcing phones from outside Sweden now (Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021). Consumers are extensively holding

on to old phones in their homes, offices or storage units and preventing the phones from being reintegrated into the repair market.

Whilst consumer behaviour and the efficiency of the collection system is causing issues, even if the old phones are collected **with the current technology for material recovery it's only economically viable to extract limited range of materials for recycling.** When the old phones are collected, recyclers and PROs struggle to recover all of the critical raw materials with existing technology. New technology would require financial investment and innovation. Said succinctly by Int. "PRO" (personal communication, April 26, 2021), "what would it gain to collect [old phones] if we are still not able to extract what [legislators] think we are extracting". Compounding this issue, **PROs prioritise material recycling and new products over repair because their money comes from material recycling. As a result, the WEEE system prioritises material recycling too (for example collected phones aren't handled carefully in a separate waste stream because recycling is the assumed default treatment).** Int. "Waste-to-Energy" (personal communication, May 12, 2021) and Int. "Association" (personal communication, May 12, 2021) both explained that the PRO El-Kretsen prioritises recovering materials to use in new devices, rather than facilitating repair, because the economics the PRO is based on the value of the material they can recycle. This means recycling is an important part of their business model. Int. "Waste-to-Energy" (personal communication, May 12, 2021) proposes intercepting repair-viable phones before they get to El-Kretsen to be recycled, because due to rough handling "if [the phone] wasn't destroyed before it came to the centre, it will be then". What this means then is Sweden's PRO is primarily invested in material recycling and thus promotes a technological system and expertise for recycling.

Current legislation is unfortunately contributing to the problem, as **legislation (such as the WEEE Directive) prioritizes recycling over repair. As a result, the Swedish WEEE system does too. Legislation needs to evolve to include and support repair meaningfully.** Int. "Researcher 1" (personal communication, April 30, 2021) explained that the WEEE Directive prioritizes recycling over repair and needs to evolve by, for example, including statistics of repaired phones on the market. If the underlying EU law influencing Sweden's WEEE system has this recycle over repair bias, it will be reproduced in the system and actors – limiting the repair transition. Thus, we see that **Sweden's WEEE system is still linear in some ways.** A linear economy isn't built to preserve the embedded value of products. To highlight some of the issues: repair-viable phones are still being recycled, there is still room for collection targets to improve, and illegal dumping of phones outside the EU is occurring (Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; K. Whalen, 2020). As Int. "Researcher 2" (personal communication, March 5, 2021) states, "we are in a linear system, with things coming out here and there to facilitate circularity". The negative features outlined in this section illustrate this complexity of trying to modify a linear system for circularity, of attempting to build a repair regime on a linear foundation.

4.4 (RQ1) Cellphones are unique as an electronics group

Figure 4-3 further below summarizes the ways in which cellphones as an electronics group are unique in Sweden. These reasons are categorized as economic, technical, legal, social, environmental, and collection. The reasons are numerous, so for brevity in this section I shall highlight only 3 of the points I find most interesting about why cellphones are unique.

From an economic perspective as shown by the diagram, **about 5 manufactures dominate 95-98% of the world's phone market.** With a small number of powerful producers, the approach they take to repair affects a disproportionate portion of the market. The repair transition must involve these actors due to the lion share they control. As Int. "Association"

(personal communication, May 12, 2021) puts it, the big transformation will occur if the legislators or these producers decide to change the system.

From a technical perspective as shown by the diagram**, phones today are a small product that currently contains critical raw materials the original WEEE system wasn't designed to treat.** It is therefore difficult for the WEEE system that was in place before the explosion in the smartphone market occurred to adapt to the new materials. As Benson (2021) puts it, "it's a device that includes materials we didn't know of and didn't use […] when we set up the system. The materials we were [extracting] were more basic".

Figure 4-3: Cellphones are a unique electronics group in Sweden's WEEE system for Thematic Finding 4.4

Economic uniqueness of phones
- New phones are cheap
- ~5 manufacturers dominate 95-98% of the world phone market
- Have high economic and material value
- Have high unused embedded value
- Functioning second-hand market
- No functioning market for materials recovered from phones
- In SE repair costs are prohibitively high
- Producers find it expensive to conduct repair

Collection uniqueness of phones
- Collection rate for phones is high and we rely on retailer collection systems
- Collected phones are sometimes exported and dumped outside Sweden
- Producers aren't getting phones back because of other actors.

Technical uniqueness of phones
- A small product that currently contains critical raw materials the original WEEE system wasn't designed to treat
- No good recycling methods to extract all valuable materials
- Not treated as a separate fraction of WEEE
- The condition, quality and geographic dispersion of used phones is not homogenous
- Design does not allow repair or a long lifespan
- Compatible but poor-quality counterfeit spare parts often necessary because producers refuse to manufacture parts

Social uniqueness of phones
- A significantly prolific device in society
- High device hoarding of old cellphones
- Phones are improperly sorted by consumers, leading to premature recycling
- SE consumers of 2nd hand devices greatly demand phones but want newer models

Legal uniqueness of phones
- Offering services like repair and guarantees makes reuse attractive to consumers
- No legislation requiring actors to track phones removed from market
- Legislation like Right to Repair can increase phone reuse

Environmental uniqueness of phones
- Materially, the only thing that matters is the phone being reused
- Majority of env. impact comes from the production phase

Data Sources: (Alexander, 2021; Benson, 2021; Halldórsson, 2019; Haskew, 2021; Holmström, 2021b; Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021; Karlberg, 2021; Nordbrand, 2021; Sandell, 2021; K. Whalen, 2020; Wu, 2021)

From a collection perspective as shown by the diagram, **producers aren't getting phones back because of other actors.** There is competition for the highly valuable phones – and it is fierce. There is a limited supply of phones in the WEEE system. It is assumed that producers are attempting to collect phones for recycling, since (as per earlier comments) the data has shown they are resistant to repair. In the current WEEE system, repairers/refurbishers and
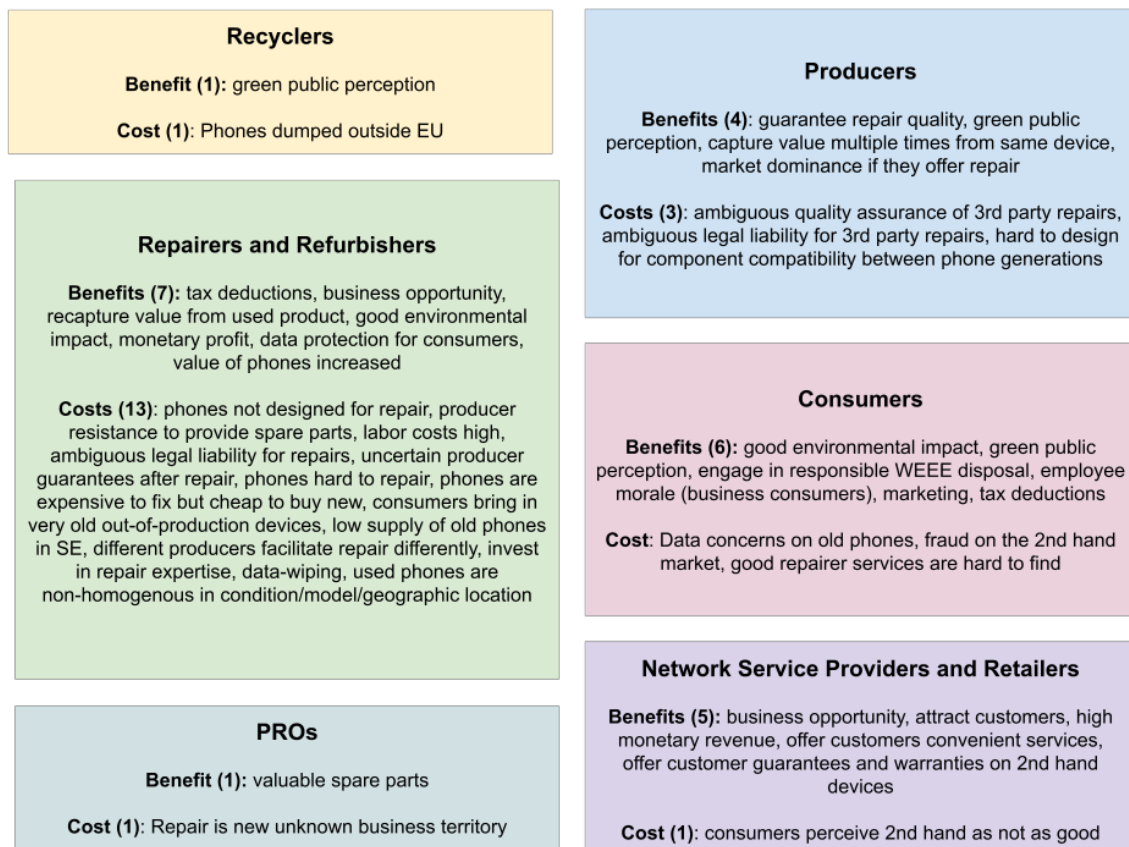
recyclers also find themselves competing for the same singular waste flow of phones. In a circular economy WEEE system, refurbishers and recyclers would occupy separate but complementary parts of the WEEE system, with different non-competing flows of devices. This is described succinctly by Whalen (2020) as follows:

- "There are 2 main strategies businesses can take to participate in a CE: **slowing loops** (extending the life of products) or **closing loops** (extending the useful life of material resources)."
- "For the example of phones, slowing means <u>repairing</u> the device to extend its useful life."
- "Closing loops then […] the phones can be <u>recycled</u> afterwards"

This competition for a limited supply of waste phones prevents actors from acting in a manner most aligned with their role is a circular WEEE system. If producers facilitated collection for repair (where possible) and recycling (where necessary), the competition would not be necessary.

4.5 (RQ2 and RQ3) There are multiple benefits, costs, and incentives for phone repair being experienced by different actors

Figure 4-4: Benefits and costs of repair <u>and</u> which actors receive them

Recyclers

Benefit (1): green public perception

Cost (1): Phones dumped outside EU

Repairers and Refurbishers

Benefits (7): tax deductions, business opportunity, recapture value from used product, good environmental impact, monetary profit, data protection for consumers, value of phones increased

Costs (13): phones not designed for repair, producer resistance to provide spare parts, labor costs high, ambiguous legal liability for repairs, uncertain producer guarantees after repair, phones hard to repair, phones are expensive to fix but cheap to buy new, consumers bring in very old out-of-production devices, low supply of old phones in SE, different producers facilitate repair differently, invest in repair expertise, data-wiping, used phones are non-homogenous in condition/model/geographic location

PROs

Benefit (1): valuable spare parts

Cost (1): Repair is new unknown business territory

Producers

Benefits (4): guarantee repair quality, green public perception, capture value multiple times from same device, market dominance if they offer repair

Costs (3): ambiguous quality assurance of 3rd party repairs, ambiguous legal liability for 3rd party repairs, hard to design for component compatibility between phone generations

Consumers

Benefits (6): good environmental impact, green public perception, engage in responsible WEEE disposal, employee morale (business consumers), marketing, tax deductions

Cost: Data concerns on old phones, fraud on the 2nd hand market, good repairer services are hard to find

Network Service Providers and Retailers

Benefits (5): business opportunity, attract customers, high monetary revenue, offer customers convenient services, offer customer guarantees and warranties on 2nd hand devices

Cost (1): consumers perceive 2nd hand as not as good

Data source: (de Kluijver, 2021; Halldórsson, 2019; Haskew, 2021; Holmström, 2020, 2021a, 2021a, 2021b; Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Researcher 2", Project Manager at

Swedish research institute, personal communication, March 5, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021; Karlberg, 2021, 2021; Lampa, 2021; Sandell, 2020; Vallauri, 2021; K. Whalen, 2020; Wu, 2021)

In Figure 4-4 above, I have indicated the actors for which I could identify benefits and costs for engaging the repair of cellphones in my data. Most notably, a count of 7 benefits and 13 costs was identified for **repairers and refurbishers**, a count of 4 benefits and 3 costs was identified for **producers**, a count of 6 benefits and 3 costs was identified for **consumers,** and a count of 5 benefits and 1 cost was identified for **network service providers and retailers**.

Some of the **notable benefits refurbishers and repairers** receive include tax deductions, recapturing value from used products and monetary profit. However, there are many **costs**. Phones are not designed for repair, labor costs are high, there is a low supply of phones coming in, and that supply of phones is non-homogenous in composition. Some of these costs are directly influenced by other actors in the WEEE system as well (such as providers not making spare parts). A **notable benefit that producers** receive is the ability to capture value multiple times through a device produced once if they engage in repair. This is contrasted with the **costs** they would otherwise incur if (as shown by the diagram) they allow third party repairers to perform this repair function on the market. **Private and business consumers benefit** from tax deductions and making a good environmental impact, among other things. This group however remains concerned about data security, fraud, and the availability of reliable repair services. **Network service providers benefit** from offering customers convenient repair services, but they must content with customer skepticism for the quality of secondhand phones.

Figure 4-5 below provides additional insight into the benefits-actors data presented by Figure 4-4 by showing the proportional relationship between the different incentives for repair actors experience. The figure shows that actors are overwhelmingly incentivized by economic (41 coding references) and legal forces (30 coding references) – essentially money and the law. Upcoming legislation in the EU and in Sweden (Holmström, 2021b) that encourage new business opportunities in repair (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021). Social (24 coding references) and environmental (24 coding references) incentives for repair are proportionally similar, that perhaps they both present an equivalent draw for actors.

It is clear to see that the dynamics of actors involved in repair and the benefits they get from doing is complicated.

Figure 4-5: NVivo13 Treemap showing codes compared by number of coding references: Repair incentives. (Query Parameters: Sized by coding references, Codes compared by number of coding references)

4.5.1 RQ3: Repair must make economic sense for actors to engage in it

Table 4-3: Core findings from data analysis of interviews and web-materials for Thematic Finding 4.5.1

Core Finding	Corresponding data sources
For the various actors engaged in WEEE management, their **business models are an important element** that needs to be considered when discussing the transition to a repair regime. **It has to make business sense** for these actors to engage in repair.	(Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)
The actors' **business interests** affect how much they push for repair	(Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021)

A recurring theme throughout the data was how repair had to be economically viable in order for actors to engage in it in the WEEE system. **For the various actors engaged in WEEE management, their business models are an important element that needs to be considered when discussing the transition to a repair regime. It must make business sense for these actors to engage in repair.** WEEE management always has to make financial sense (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021). **The actors' business interests affect how much they push for repair** from their position in the system. They push themselves towards phone repair only so far as it aligns with their economic interests <u>and in turn,</u> they accommodate society's push on them to repair only so far as it alights with their economic interests. As stated by Int. "PRO" (personal communication, April 26, 2021) "in the end someone is paying" money regardless of the good intentions of the actors.
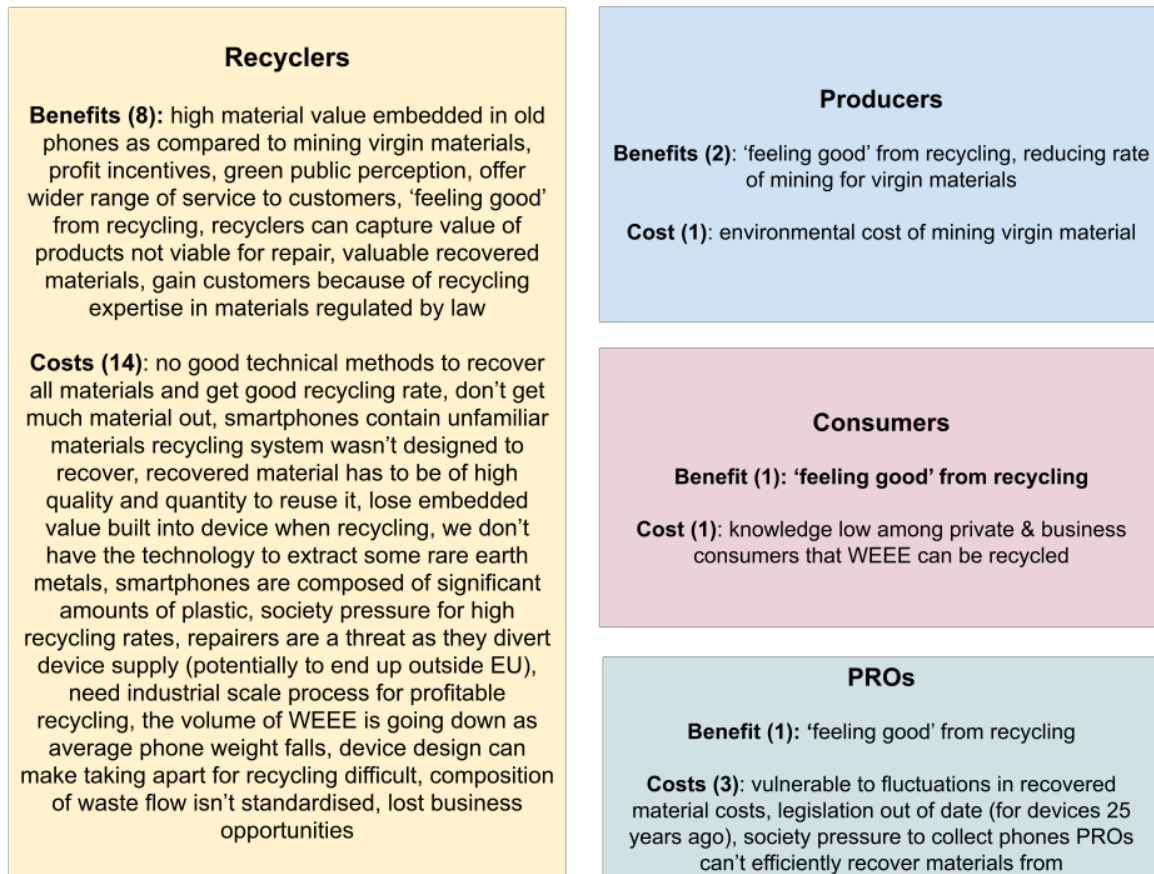
When it comes to shifting from recycling regime to repair regime, actors are limited by the flexibility of their current business model. Unless actors want to radically transform the nature of their business, where this "limited flexibility" fact can be leveraged to enable the repair transition is by:

1. Ensuring agreements between actors for facilitating repair are **transparent** with clear objectives beforehand. This was the case between "Recycler" and El-Kretsen as described by Int. "Recycler" (personal communication, April 22, 2021).
2. Ensuring that either actors are **paid** to engage in repair activities **or** what is asked for them is only **what is possible** under their current business model. This insight is informed by comments made by Int. "PRO" (personal communication, April 26, 2021) and Int. "Waste-to-Energy" (personal communication, May 12, 2021).
3. Where none of the above are possible, **fully legislating repair** activities together with **other system changes** will ensure there are no incomplete policy motions from policymakers. It is not enough to ask actors to perform repair acts if no other parts of

the system will accommodate those changes. This insight is informed by comments made by Int. "PRO" (personal communication, April 26, 2021)

4.6 RQ2 and RQ3: There are multiple benefits, costs, and incentives for phone recycling being experienced by different actors

Figure 4-6: Benefits and costs of recycling <u>and</u> which actors receive them

Recyclers

Benefits (8): high material value embedded in old phones as compared to mining virgin materials, profit incentives, green public perception, offer wider range of service to customers, 'feeling good' from recycling, recyclers can capture value of products not viable for repair, valuable recovered materials, gain customers because of recycling expertise in materials regulated by law

Costs (14): no good technical methods to recover all materials and get good recycling rate, don't get much material out, smartphones contain unfamiliar materials recycling system wasn't designed to recover, recovered material has to be of high quality and quantity to reuse it, lose embedded value built into device when recycling, we don't have the technology to extract some rare earth metals, smartphones are composed of significant amounts of plastic, society pressure for high recycling rates, repairers are a threat as they divert device supply (potentially to end up outside EU), need industrial scale process for profitable recycling, the volume of WEEE is going down as average phone weight falls, device design can make taking apart for recycling difficult, composition of waste flow isn't standardised, lost business opportunities

Producers

Benefits (2): 'feeling good' from recycling, reducing rate of mining for virgin materials

Cost (1): environmental cost of mining virgin material

Consumers

Benefit (1): 'feeling good' from recycling

Cost (1): knowledge low among private & business consumers that WEEE can be recycled

PROs

Benefit (1): 'feeling good' from recycling

Costs (3): vulnerable to fluctuations in recovered material costs, legislation out of date (for devices 25 years ago), society pressure to collect phones PROs can't efficiently recover materials from

Data sources: (Benson, 2021; Ebin, 2021; Holmström, 2021b; Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021; Int. "Recycler", Business Specialist of Swedish Recycler, personal communication, April 22, 2021; Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021; Nordbrand, 2021; K. Whalen, 2020)

In Figure 4-6 above, I have indicated the actors for which I could identify benefits and costs for engaging the recycling of cellphones in my data. Most notably, a count of 8 benefits and 14 costs was identified for **recyclers**, a count of 2 benefits and 1 cost was identified for **producers**, a count of 1 benefit and 3 costs was identified for **PROs.**

Some of the **notable benefits recyclers** receive include the fact that by recycling they can capture the value of products that other actors in the system cannot access, and they can attract customers who are required by law to recycle regulated materials. As shown in the diagram, **costs recyclers** face are many, one of which is that recyclers actually lose the embedded value built into devices when they take them apart to recycle. Some costs also seemed quite

fundamental, such as the fact that we don't have advanced enough recycling technology to retrieve all the critical raw materials producers are putting into modern-day smartphones. Some of the **notable benefits producers** receive from recycling include lessening their dependence on mining virgin resources, even though there is still an **environmental cost** to the mining that they cannot avoid. Some of the **benefit PROs** received from recycling was limited to 'feeling good' about engaging in recycling, whereas the substantial costs they face were being vulnerable to price fluctuations in the recovered materials, the legislation controlling their activity being out of date and being pressured to collect phones they cannot properly recover materials from.

Figure 4-7: NVivo13 Treemap showing codes compared by number of coding references: Recycle incentives. (Query Parameters: Sized by coding references, Codes compared by number of coding references). The size of each box is proportional to the number of coding references.
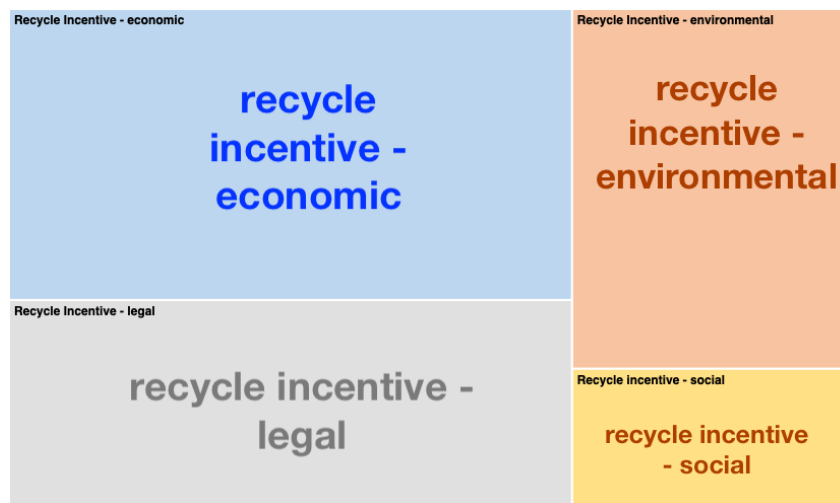

Figure 4-7 above provides additional insight into the benefits-actors data presented by Figure 4-6 by showing the proportional relationship between the different incentives for recycling actors experience. The figure shows that actors are overwhelmingly incentivized by economic (21 coding references), legal (15 coding references) and environmental forces (13 coding references) – essentially money, the law, and the environment. The codes showed that there are many factors contributing to these driving forces. One **legal incentive** is that the WEEE Directive incentivizes recycling and not much repair, complete with recycling targets (Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021). One **economic incentive** is there is also a market for recovered materials from recycled goods (Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021). Finally, **one environmental** incentive is that we have to determine how we can circulate waste as a resource in our society to supplement and ease the burden of the mining of primary resources (Johansson & Despeisse, 2019; K. Whalen, 2020). **Social incentives** for recycling (5 coding references) are proportionally smaller with fewer codes, perhaps indicating the social dimensions of recycling are not as powerful a draw for actors as the other three incentives.

What these two figures reveal is that overall recyclers are driven to recycle phones because of economic, legal, and environmental factors, even though once they do participate in recycling they are faced with more costs and benefits. Social incentives to recycle are low, reflected in how some of the benefits for multiple significant actors are limited to little more than intangible individual sentiments (i.e., 'feeling good' for participating in recycling).

4.6.1 RQ2: The challenges encountered during phone repair can present opportunities for phone recycling

A theme that stood out when I analysed the benefits-costs-incentives actors face for repairing and recycling phones was that something that was a disadvantage for one regime was sometimes an advantage for the other. Specifically, when it came to the economic, social, legal, and environmental benefits/costs actors encountered when they recycled cellphones, what was a challenge for repair actors sometimes presented opportunities and benefits for recycling actors. In Webinar A, Wu (2021) presented a session titled "Circular economy of electronics - the reuse perspective". In it, she presented a list of challenges and opportunities to electronics reuse in Sweden:

1. *Consumer perception and behaviour*
2. *Pricing favors linear systems - it is costly to reuse, than buy new*
3. *Low integration of circular procurement*
4. *Lack of policies to support reuse and second hand - most policies support recycling, but we need ones for reuse and secondhand*
5. *Lack of industry standards and definitions for circular design that facilitate the repair process for electronics*

So corresponding to the insights (in **bold** below) presented by Wu (2021) above, I propose that (text after arrow →):

- **Consumer behaviour and perception do not support repair**. → They favor recycling and other waste treatment methods for WEEE. As a result, repair/reuse value cannot be captured because consumers are not engaging accordingly.
- Secondly, **pricing favors linear systems**. → So, when consumers buy new devices instead of repairing, those unrepaired viable electronics are recycled instead or otherwise managed in the waste management system. This also means it is costly to repair devices rather than buying them new (due to high labor costs, logistics associated with repair etc.).
- Thirdly, **where there is low integration of circular procurement** → instead devices are by default procured in a linear system that often concludes in the recycling of viable electronics.
- Fourthly, where there is a **lack of policy structure to support reuse and secondhand electronics** → there instead policy support for recycling. This means that actors in repair are working against a legal system incentivising recycling, and incurring the costs that come from swimming upstream against the tide
- Fifthly, **where there is a lack of industry standards and definitions for circular design to facilitate electronics repair** → there is instead linear design that runs from "product" to "waste", wherein recycling is a waste management option for said "waste'. This also means that without a nurturing environment for repair, actors are instead working in a linear climate antithetical to their more circular business models. A lack of standards for circular design means repair actors are repairing devices with varying degrees of circular design, without a standardised approach. Such irregularity incurs costs like labor, efficiency, unique spare parts and so on.

As stated by Wu (2021) and seconded by Int. "PRO" (personal communication, April 26, 2021), our system needs to work on more than just collection and takeback of electronics. Repair actors cannot efficiently operate in a system antithetical to circular business models. As Wu (2021) says, the system must be redesigned to better capture this repair value.

4.7 RQ3: Actors face various barriers and conflicts in engaging the recycle-to-repair transition

Throughout the data analysis I noted that actors faced various barriers and conflicts that got in the way of engaging with the repair of cellphones. In fact, at times, I observed that the recycling regime acted as a barrier to the repair regime – preventing actors from doing more even if they wanted to. Figure 4-8 below shows the categories of barriers and conflicts I identified blocking actors from transitioning from recycling to repairing cellphones.

Figure 4-8: NVivo13 Treemap showing codes compared by number of coding references: Barriers and conflicts to the recycle-to-repair transition. (Query Parameters: Sized by coding references, Codes compared by number of coding references). The size of each box is proportional to the number of coding references.

The three most prominent dynamics (with the most coding references) are described below. All barriers and conflicts are ranked in descending order of prominence in the data:

(1) Social perception of repair among WEEE actors (23 coding references): The more actors work with repair, generally the more sure they felt they could do it more (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021). However, for those who operated completely differently (actors tied to systems of recycling) they were feeling social pressure to get with the repair program. In addition, because of how actors like consumers thought of cellphone repair as not a priority, they were prone to behaviours like device hoarding and demanding very new secondhand phones (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "Researcher 2", Project Manager at Swedish research institute, personal communication, March 5, 2021). PROs also had to start evolving away from the mindset of taking apart viable phones for material recovery (Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021). A key take-home message from Wu (2021) was that as a society we must rethink how we use electronics.

(2) Legislation doesn't facilitate repair nor make it explicitly mandatory (17 coding references):: As explored under previous thematic findings, the law does not currently prioritise phone repair nor legislate it to be mandatory for key actors (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021). Legislation could push the dominant phone producers to repair electronics (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021). Legislation would also give

PROs a concrete legal reason to invest in proper material recycling mechanisms for phones and give them a legal reason to push other actors to repair phones (Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021).

(3) Current technological landscape is not established for repair. There is also difficulty with repair logistics (17 coding references):: Equipment used by actors like PROs to collect phones is rough (Int. "Waste-to-Energy", CEO of Swedish Waste-to-energy company, personal communication, May 12, 2021). Equipment used by most recyclers is only suited to extracting materials from destroyed devices (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021; Int. "PRO", VP of Swedish PRO, personal communication, April 26, 2021). Actors who do choose to repair must invest in logistics like technical knowledge and labor (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021). The fundamental challenge between repair processes and recycling processes is that recycling and repair ask for different scales of operation – recycling is at an industrial scale to capture trace materials, whereas repair is at a small scale driven by manual labor. (Int. "Association", CEO of Swedish Waste management and recycling association, personal communication, May 12, 2021).

Other barriers and conflicts are were flagged by the interviewees and speakers: (4) An economically viable business case for repair is critical, (5) Some actors are prioritizing linear consumption, (6) Producers are not designing phones to allow repair, (7) More collaboration and communication is needed between WEEE actors, and (8) Collection system does not facilitate repair.

These barriers and conflicts show that transitioning from recycling to repairing of phones is difficult for all actors in the WEEE system. With the context provided by earlier thematic findings, it is easier to understand that each actor has a unique role to play and tailored obstacles to overcome. With the barriers and conflicts uncovered from the data, it was not surprising that interviewees and speakers were also discussing potential solutions to overcome challenges and increase phone repair. This is explored in the section below.

4.8 RQ3: Actors are thinking of various future solutions and innovative changes to the WEEE system that can increase phone repair

As shown in Figure 4-9 further below, throughout the research process actors were proposing various future-oriented solutions to facilitate more repair of cellphones. These solutions are visualised in Figure 4-9 below. The three most prominent dynamics (with the most coding references) are described below. All solutions are ranked in descending order of prominence in the data:

(1) The importance of designing for repair (18 coding references): Eco-design is crucial for facilitating the repair of phones, otherwise when manufacturers actively design against repair it makes it impossible for other repairers to make even simple fixes (Sandell, 2021; K. Whalen, 2020). A company called Fairphone disrupted the market with its repair friendly phone and then it demanded its supplier use conflict-free materials – and because that supplier also supplied other much larger phone producers, the industry standard automatically changed (K. Whalen, 2020). Actors at all levels can innovate and trigger change in how phones are designed.

(2) Adopting different business models and practices to facilitate repair (15 coding references): As explored in previous thematic findings, actors can begin offering services and conducting business practices that support repair. If the dominant phone producers changed their busines model to facilitate repair it would transform the entire landscape of phone repair (Int. "Association", CEO of Swedish Waste management and recycling association, personal

communication, May 12, 2021). If retailers like Dustin and Telia continue their plans to scale business models of selling pre-used phones, takeback and bundling of phones, and offering phone leasing with repair support services more transformation would be seen (Lampa, 2021; Nordbrand, 2021).

Figure 4-9: NVivo13 Treemap showing codes compared by number of coding references: Future Solutions and Innovative system changes. (Query Parameters: Sized by coding references, Codes compared by number of coding references). The size of each box is proportional to the number of coding references.
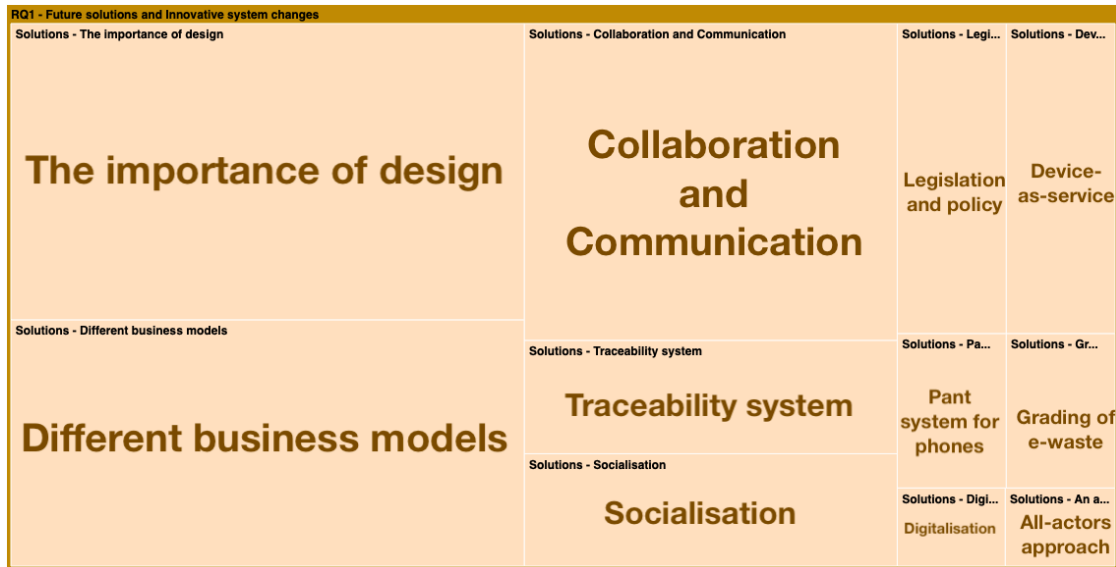
(3) Collaboration and communication between actors to facilitate repair (14 coding references): WEEE actors must have good communication otherwise they risk being unhappy and resenting each other (Int. "Researcher 1", EPR and Swedish waste policy researcher, personal communication, April 30, 2021). As stated by Nordbrand (2021), "A shift together is key to making [the circular economy] happen". Collaboration across multiple value chains is necessary to pushing forward circularity in phones (Holmström, 2021c). Researchers must communicate their knowledge with other actors, entirely new and different partnerships will need to be formed, and throughout it all we must supportively share experience and inspiration (Brändström, 2021; Holmström, 2021a; Lindquist, 2021).

Other solutions are also proposed by the interviewees and speakers: (4) Socialisation to encourage a culture of phone repair across all actors, (5) Establishing a traceability system for phones, such as a "product passport", (6) Offering device-as-service for phones, (7) Legislation and policy supporting repair, (8) Establishing a quality-grading system for e-waste, (9) Establishing a pant system for phones, (10) An all-actors approach to waste management, and (11) Digitalisation and digital solutions for future electronics.

These solutions are so hopeful. They indicate that actors are willing and thinking about ways to improve Sweden's WEEE system so that phones can be repaired more. Despite the barriers and conflicts they face, actors are willing to consider a different way of doing things. Taken together with (a) the thematic findings about Sweden's WEEE system in practice when it comes to cellphones and (b) the thematic findings about how benefits-actors phone-repair dynamics work – it is good to see actors proposing changes that will improve the state of phone repair in Sweden.

5   Discussion

5.1   Discussing Findings against that which was already known

Figure 5-1 The thematic findings from my study connecting to the coordinating Thematic findings from existing body of knowledge
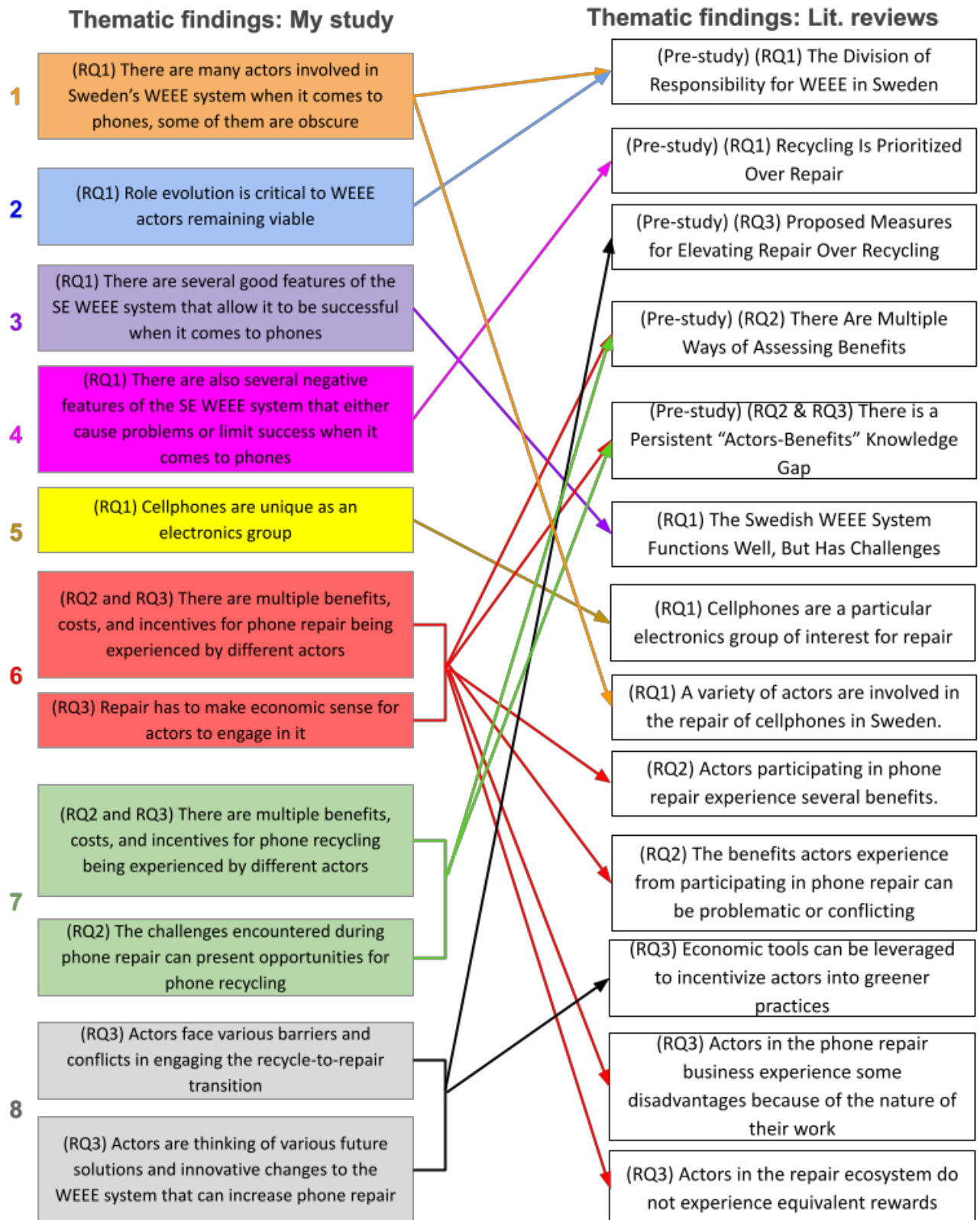
Figure 5-1 above gives an overview summarising the thematic findings of my study thematic findings from my literature reviews. I have drawn lines that connect the thematic findings from my study to the thematic findings from my literature review. Below, I have 4 discussion points that I have drawn from a comparative analysis of the two sets of thematic findings.

5.1.1 Discussion Point 1: When it comes to phones, Sweden's WEEE system is complicated

Connections 1, 2, 3, 4 and 5 shown in Figure 5-1 reveal just how complex Sweden's WEEE system is when it comes to cellphones.

Sweden's WEEE system involves many actors, to the point that the boundaries of the system are hard to draw. The decision of who is part of the WEEE management system of cellphones is tricky. In determining the roles performed by different actors, I took the approach of tagging actors that were involved in some way with WEEE management. Of course, this meant I applied judgement as to who "is involved enough". Barring legal determinants of who is considered part of the WEEE system, it appeared that actors' business models determined whether or not they could be considered part of the WEEE system. In the study, I found many more actors involved in Sweden's WEEE system than those provided in the literature.

These many actors perform complex, interrelated and sometimes overlapping roles in the waste management of cellphones. Some of the actors perform more than one role in the WEEE system, creating the scenario where multiple actors perform similar functions. The literature presented the impression that actor's roles are concrete and easy to decipher, however the study showed that actors have some flexibility and can take on additional roles beyond what they are required to do. In practice, there is deviation from the roles laid out in the theoretical understanding of the formal division of responsibility for WEEE in Sweden. Furthermore, **the study showed that WEEE actors' roles evolve over time. In practice, this evolution modifies the practical distribution of responsibility outlined in Sweden's formal WEEE policy.** As actors shift and adjust the capacity of what they do, the distribution of who does what also changes. The literature showed that actors roles are considered somewhat static. Introducing flexibility to the roles actors are expected to perform would allow some much-needed limber in the system. Ensuring that the formal WEEE policy also stays up to date and is developed in collaboration with the actors it will affect will also make the WEEE system more resilient and responsive.

Cellphones are a complex device with a complex value chain of actors. This value chain of actors must then interact with the many actors in Sweden's WEEE management system. This means that any changes to the device affect other actors in the network, and similarly to create any meaningful change in the network multiple actors must be mobilized. Complexity of the device had implications once the device reached the WEEE system, making the management of the device more difficult and intricate.

5.1.2 Discussion Point 2: Understanding of the phone repair benefits-actors dynamic has been improved

Connection 6 shown in Figure 5-1 gives us insight that fills in the knowledge gap surrounding phone repair and benefits-actors dynamics.

Phone repair is deeply complex as a service that actors offer to society *and* as a role that actors execute in the WEEE system. The literature showed that phone repair is fraught with barriers, conflicts, issues, and difficulty. The study reinforced this finding and from the words of actors in the system I gathered data about this complexity. This complexity must be

considered when we make demands for actors increase repair – by ensuring that the systemic environment supports these actors when they do engage repair.

So, we must develop a supportive environment for actors to engage phone repair within. **In order to upscale phone repair, legislation, economic factors, and the technical landscape must align and support each other.** The study showed the importance of what I term *complete gestures* – meaning all elements of the systemic environment must follow through and commit to phone repair. Factors like actor hesitation, incomplete policies, or lack of development in critical technology cannot be accommodated as we transition to increasing phone repair.

The value that actors get from repairing phones is complex because it's hard to measure and all value is interconnected. Here, I propose the terms *complex benefit* and *complex cost* as part of our understanding of the concept of complex value introduced by the multi-value domain framework CVORR. Complex benefit and complex cost need to be understood so that we know how to push actors towards phone repair. By knowing what they get out of it and what it costs them, we can understand how to guide and support them towards a phone repair regime.

5.1.3 Discussion Point 3: Understanding of the phone recycle benefits-actors dynamic has been improved

Connection 7 shown in Figure 5-1 gives us insight that fills in the knowledge gap surrounding phone recycling and benefits-actors dynamics.

Some actors have strong incentives to uphold the premature recycling of cellphones. These incentives include established technological infrastructure, legislation supporting recycling and economic drivers. The more we learn about this knowledge gap, the more we know how to encourage recyclers to push for more circularity. By understanding what is motivating actors to stick to premature phone recycling, we can understand what needs to change to stop them from doing it. It is also important to distinguish between premature phone recycling, and phone recycling of devices no longer viable for repair. This nuance will ensure the actors involved in recycling can perform their role in close alignment with the principles of "slowing loops" and "closing loops" in a circular economy.

5.1.4 Discussion Point 4: The future of repair and overcoming obstacles

Connection 8 shown in Figure 5-1 shows that despite facing challenges that tie them to the recycling regime of cellphones, many actors are still dreaming of ways to build up momentum in the repair transition. Actors envision a future of upscaled phone repair and solutions for overcoming obstacles

Despite some actors being locked in by investments in recycling and others facing barriers to their repair efforts, many actors are still developing and implementing solutions to increase the circularity of phones as an electronics group in Sweden. This is hopeful and is motivating to learn. It shows that many actors get it, they understand the importance of increasing circularity by pushing for the repair of viable phones. When the actors involved in the WEEE system improve their collective knowledge, support, and collaborate with each other to do better, and push for system evolution – the phone repair transition will gain momentum.

5.2 Reflecting on the results of my study

5.2.1 Methodological/theoretical/analytical choices

As I explored the possibilities of my research design under the RDM section of this thesis, I made choices that impacted the results I obtained in my study. A detailed reflection of each methodological choice is available under the RDM section. In this section, I will discuss (with the insight of having completed my findings) on the impact of certain methodological choices.

By conducting my **semi-structured interviews** online, I was able to record the interviews and use this to doublecheck my data. However, I found reaching out to potential interviewees intensive, and not everyone I was interested in interviewing responded or was available. I was however able to target well-established experts who were large actors directly involved in Sweden's WEEE management. This meant that I was able to capture plenty of data from each individual expert I interviewed. For the **audio-visual materials method**, I benefited from hearing what many experts thought. Since the web-materials were not customized to fulfil my own research, I had to review many materials to collect answers to my questions. I also had to disregard information and insights that were irrelevant to my research. As I reflect on this method, this method helped me gather more data from actors I wouldn't otherwise have been able to access. Together, the interviews and web-materials helped me put together a collective pool of data that could address my research questions.

In my **methods of data analysis**, I chose to develop an analytical framework based in content analysis approaches as advised by two qualitative research methodology textbooks. I also integrated synthesis matrixes into the analytical process. Thus, my analytical framework was developed from three approaches. The analytical process I developed ended up being labor and time intensive, however the analytical outputs I was able to get from the process made it worth the effort. In future, I would consider adopting only one computer-assisted content analysis approach, as it is very possible that a single approach would have been sufficient in capturing the thematic findings I found.

So, a **qualitative methodology** was selected as I found it best suited to a research problem that was difficult to quantify but could be explored qualitatively. The methods of data collection and data analysis were chosen for their ability to develop themes from gathered materials, bottom up. Qualitative research is fundamentally interpretive (Creswell, 2003), meaning that my interpretation as a researcher is engrained in the findings. As a researcher I am a black African woman, raised in multiple cultures, studying a Master's in Environmental Management and Policy at a large institution in Sweden. This thesis research has been filtered through my view of what is significant. It stands to say that other qualitative researchers might have come to different interpretations of the same research problem and materials.

5.2.2 Legitimacy and Generalisability

My research questions have been **answered to a satisfying degree** and my research aim was fulfilled. I was able to develop multiple thematic findings that responded to each of the three research questions. My research questions were **legitimate** and did help me to address what I found during the study to be a true gap in the current knowledge. I was also able to find answers that confirmed and reinforced some parts of the existing body knowledge, which indicates to me that I was indeed asking the right research questions.

The **validity** of the three research questions can be tested via various strategies articulated by Creswell (2003, 2014). In this case, I conducted a pre-study to search for and test three initial research questions worth pursuing in a master's thesis. I triangulated of evidence from multiple

data sources via the literature reviews and built a justification of why the re-developed research questions were worth pursuing. The thematic findings were established through converging multiple sources of data and disciplinary perspectives, thus adding validity to the findings of the my thesis research (Creswell, 2014).

In qualitative research, Myers (2000) states that **generalisation** is the degree to which the findings can be generalized to a the wider population. In this thesis research, the findings are on the national Swedish context and can be reasonably applied to similar geopolitical regions in a similar temporal context, for example other industrialised Nordic countries within the EU that are currently subject to the WEEE Directive. A judgement can be made that the findings from this research context are applicable to geopolitically similar regions in the world (Blaikie & Priest, 2019).

6 Conclusions

6.1 Answering my research questions

The research problem area my thesis study set out to explore was that the Swedish WEEE system promotes the recycling of repair viable WEEE. To compound this issue, little was known about which actors benefit from the choices to repair or recycle WEEE in Sweden, and how, was scant. This was all occurring within the context of increasing resource scarcity and increasing resource consumption.

The initial research aim of this thesis research was to develop an understanding of the WEEE system in Sweden in practice, to explore what benefits actors in the Swedish system reap from choices to repair or recycle WEEE, and to gain an understanding of which actors receive those benefits from repairing or recycling WEEE in Sweden.

My initial research questions developed in my thesis pre-study and initially explored in this study were:

(1) *How does the Swedish WEEE system function in practice?*
(2) *What benefits do actors in WEEE gain from participating in repair of WEEE vs recycling it?*
(3) *What actors benefit from choices to repair vs recycle WEEE in Sweden?*

Following my literature review, my re-developed research questions were:

*(1) How does the Swedish WEEE system function in practice **when it comes to cellphones**?*
*(2) What benefits do actors in WEEE gain from participating in the **repair of cellphones vs the recycling of cellphones?***
*(3) What actors benefit from choices to **repair cellphones vs recycle those cellphones in Sweden?***

As a result, my updated research aim was to develop an understanding of the WEEE system in Sweden in practice when it comes to cellphones, to explore what benefits actors in the Swedish system reap from choices to repair or recycle cellphones, and to gain an understanding of which actors receive those benefits from repairing or recycling cellphones in Sweden.

The conclusions my analysis supports (my claims) are presented below as answers to these re-developed research questions

6.1.1 Answer to RQ1: How the Swedish WEEE system functions in practice when it comes to cellphones.

Sweden's WEEE system is organised according to an Extended Producer Responsibility approach that is legally mandated by law through the EU WEEE Directive. Each actor performs a role in this system, wherein producers specifically are required to financially and logistically organize the treatment system of WEEE from homes and businesses. The research identified 15 unique actor groups (including Producers, Recyclers, Consumers, Municipalities etc.) involved in the WEEE management of cellphones as a specific group of electronics. The roles actors play are formalized by law and agreements, but actors sometimes evolve to perform other roles or expand on their function beyond what is required of them. Several good features of Sweden's WEEE system allow it to be successful – including elements such as accountability structures, a singular collection system for WEEE and a strong culture for sustainability amongst Swedish consumers. Negative features of Sweden's WEEE system cause problems though – such as the law prioritizing recycling over repair, limited technical capacity for material recovery and device hoarding behaviours amongst private and commercial consumers. Lastly,

cellphones are a unique electronics group – and that uniqueness affects how they are managed in Sweden's WEEE system. 6 categories (economic, technical, legal, collection, social and environmental) containing a total of 26 unique characteristics were identified in the study. My research showed that cellphones as an electronics group involved a great deal of practical complexity in Sweden's WEEE system – far greater than the complexity of WEEE management presented in the formal theoretical delineations of the system.

6.1.2 Answer to RQ2 and RQ3: What benefits actors get from repairing cellphones vs recycling them, and which actors benefit from choices to repair or recycle WEEE in Sweden.

My research was able to determine the **benefits, costs, and incentives** a **limited group of 6 actors** experienced when they engaged in repairing cellphones. For recyclers, repairers/refurbishers, PROs, producers, consumers, network service providers and retailers I was able to identify economic, legal, social, and environmental costs, benefits, and incentives for phone repair. The list of benefits and costs I was able to find was fairly extensive for the identified actors, though the list was longer for repairers and refurbishers. As I was only able to determine the phone repair benefits-actors dynamics for a limited group of actors, there is potential for future research here. However, for the purposes and scope of my thesis research, I am satisfied by the extent of these answers I received for RQ2 and RQ3.

My research was also able to determine the **benefits, costs, and incentives** a **limited group of 4 actors** experienced when they engaged in recycling cellphones. For recyclers, PROs, producers, and consumers, I was able to identify economic, legal, social, and environmental costs, benefits, and incentives for phone recycling. Producers, consumers, and PROs had a shorter list of benefits and costs, whilst recyclers had the longest list. Because I was only able to determine the phone recycling benefits-actors dynamics for a limited group of actors, there is potential for future research here. However, for the purposes and scope of my thesis research, I am satisfied by the extent of these answers I received for RQ2 and RQ3.

6.2 Practical implications and recommendations for non-academic audiences

Below I have organised the short-term and long-term implications and recommendations for my three target audience groups.

(1) Peers and instructors from the Environmental Management and Policy Master's program

The benefits-actors knowledge gap when it comes to phone repair and phone recycling is a frontier of research that needs more exploration.

- **Short-term:** My first recommendation would be to encourage more master's thesis research in this area.
- **Short-term**: I also recommend partnering with actors in the Swedish WEEE system to better understand the complex value dynamics they experience in the system. Research projects in this area or master's consultancy projects in this area would be useful.
- **Long-term**: As a Swedish research institution, the IIIEE could invest in research projects on phone repair that feed knowledge into actor groups like governmental bodies and PROs – allowing these actor groups to benefit from the research the IIIEE is doing

(2) The Swedish Ministry of the Environment

With the thematic findings I have presented, the ministry can take this knowledge to work out how they can elevate phone repair as a public governmental body actor. This could involve

- **Short-term**: Host workshops with actors in the WEEE system to understand the elements of WEEE legislation that are not aligned with actor's needs.
- **Long-term**: Looking into what can be done to encourage European WEEE legislation to be revised in a manner that accounts for the experiences of actors and circular ambitions of wider society.

(3) Actors involved in electronics repair activities for a circular economy in Sweden

These actors should collaborate with each other and with other actors in Sweden's WEEE system to elevate phone repair. This can be done by:

- **Short-term**: Hosting workshops to discuss the state of affairs for phone repair across different actor groups
- **Short-term**: Engaging with policymakers to communicate the needs of repair actors and what it will take to mobilise the phone repair transition
- **Long-term**: Evaluate their business models to ensure that they are offering repair services efficiently and effectively to society

6.3 Recommendations for future research

My work contributes to the body of research by providing answers to the benefits-actors knowledge gap in phone repair and recycling. I have presented thematic findings grounded in the words of expert actors in Sweden's WEEE system. Current literature (as shown in the literature review) was extremely limited in this topic area. By exploring this frontier, I have started to lay some of the groundwork other researchers could use to go further. Specifically, I have contributed the following knowledge:

- The discrepancies and alignments between how Swedish WEEE actors manage phones in reality as compared to what the theoretical understanding says they do.
- The benefits/costs/incentives a limited group of actors experienced when they repair phones in Sweden's WEEE system.
- The benefits/costs/incentives a limited group of actors experienced when they recycle phones in Sweden's WEEE system.
- Potential solutions for overcoming barriers to the phone repair system transition.

My recommendations for future research would be for further exploring the actor-benefit dynamics within phone repair and recycle. It would be beneficial as well if future research explored the concept of complex value domains in the WEEE system – to do this, more elements of the CVORR framework could be used. In my research I was able to uncover some answers for a group of actors, but not for all actors involved in Sweden's WEEE system. In this way, future research could build on what my research has found. A potential research question would be:

> *What **complex value** do **actors** in the Swedish WEEE system gain from recycling cellphones vs repairing them?*

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Appendix 1: Interview protocol

Procedural Note: Interview questions are customised to the stakeholder group being interviewed. As a result, there are three lists of questions. Each is modified for the group in question:

1. PROs
2. Refurbishers/repairers/remanufacturers and Recyclers
3. Researchers and Other Stakeholders (this being researchers/other experts who know about the industry)

<mark>List of potential interviewees</mark>

Name	Contact made?	Contact info	What they contribute
Potential #1 Nordic Inter-governmental body	Declined	**Anonymized**	**Anonymized body** published a report that gave a lot of good information on my research area. Discussing with them could provide more insight and leads, as they are situated in the policy environment of this issue
Potential #2 Researcher/consultant	No Answer	**Anonymized**	He worked on the **Anonymized** report mentioned above. **Anonymized** shared connections at the IIIEE
Potential #3 Sustainability manager, Refurbisher #1	Declined	**Anonymized**	As a company directly involved in refurbishment, she can comment on the sustainability dynamics, as well as address all 3 research questions. From Carl: "**Anonymized refurbisher** will have comments on the potential conflicts between repair and recycling"
Potential #4 PRO	Done	**Anonymized**	From Carl: "potential #4 knows a lot and has many good ideas"
Potential #5 Recycling	Done	**Anonymized**	From Calle: potential contacts at **Anonymized recycler**

Potential #6 Refurbisher #2	Declined	**Anonymized**	Repair/remanufacturer that also has the express goal of preventing recycling of viable electronics. Potential #6 has a good overview
Potential #7 Researcher	Declined	**Anonymized**	Co-authored the paper by the **Anonymized body**
Potential #8 Researcher	Done	**Anonymized**	Co-authored the paper by the **Anonymized body**
Potential #9 Association	Done	**Anonymized**	Identified through Carl
Potential #10 Waste-to-energy	Done	**Anonymized**	Identified through Carl
Potential #11 Recycler	Declined	**Anonymized**	Identified through Carl
Potential #12 Researcher	Done	**Anonymized**	Identified through Carl

A: Interview questions for PROs

Opening statement (said to all interviewees): Thank you for agreeing to be part of my interviews for my master's thesis. I am excited to speak with you because there is so much you know I could learn from. Before we begin, are you comfortable with me recording this interview? I would be the only individual who will hear/see it, and it will be used strictly for note taking and data analysis only. In addition will not share the file with other individuals.

The SE WEEE system - Based on RQ1

4. How does your company **operate** in the Swedish cellphone repair/recycling market? What is your primary role in a simplified statement?
5. What are the challenges and difficulties within Sweden's WEEE system?
    a. What are **good features** of the Swedish WEEE system that allow it to be successful?

      b.   What are some **negative features** of the system that prevent successes?

6. What are some things that are **unique** to how cellphones as an electronics group are managed within the Swedish WEEE system?

7. Previous research with my classmates looked into PRO's potential roles in "closing loops by targeting solutions higher in the Waste Hierarchy and promoting reuse and repair before recycling of e-waste".   As said by my classmates of your role, "[PRO] is largely a logistics company for several parts of the value chain."

      a.   As a PRO, what are some **difficulties** you encountered as you moved to push for repair of cellphones in your spheres of influence?

8. The Swedish law supports recycling. The objectives of PROs are towards recycling. The push for repair is largely outside the legal framework, since recycling is currently the law.

      a.   As a PRO, **how** are you integrating the push towards working in repair, despite being contractually obligated to recycling electronics like cellphones?

      b.   Is this environmental pressure on recyclers beneficial/harmful towards making these actors work in repair?

9. In December, [PRO] severed the agreement with [Recycler] (a company hired [to perform task]) after details of mishandling of material came to light.

      a.   When such problems happen with companies you collaborate with, what serious obstacles in Sweden's waste management of used phones are made evident to you as the primary PRO in the country?

      b.   What benefits do you receive as a PRO from outsourcing to other companies, as you formerly did with [Recycler]?

10. More actors are moving from recycling to repairing cellphones. As a PRO established in a recycling regime, how do you see your role evolving with the actors you work with?

Actors - Based on RQ3

11. Recycling vs repair:
      a.   Can you list the actors involved in **phone refurbishment/repair** in Sweden?
      b.   Can you list the actors involved in **phone recycling** in Sweden?

12. As a PRO actor, you only have legal obligations in the WEEE system to collect for recycle. As you make moves to increase circularity you are enabling repair:
      a.   Are there conflicts between <u>the law</u> and <u>your business</u> when it comes encouraging actors to repair phones in your industry?
      b.   How do you address the recycle targets you need to meet if you start encouraging phone repair/reuse?

13. Do you believe the recycling regime is a barrier to phone repair?

14. As you work with recyclers, what are the problems you see actors experiencing as transition their services from recycling to reuse/repair (logistics, culture, market etc.)

15. For a PRO, whose market position developed because of changes in legislation, what are the benefit opportunities for you when it comes to the repair market?

Benefits - Based on RQ2

16. What are some of the benefits the actors you listed in Q8 gain when they **repair cellphones**?
      a.   Can you list some economic, social, and environmental benefits?

b. Are there costs or forfeited benefits when actors choose to repair?
c. Does the system have the legal/social/environmental incentives to push actors to repair?
d. As a PRO actor, what is the primary benefit you gain from repairing or recycling phones?

17. What are some of the benefits these actors you listed in Q8 gain when they **recycle cellphones**?

e. Can you list some economic, social, and environmental benefits?
f. Are there costs or forfeited benefits when actors choose to recycle?
g. Does the system have the legal/social/environmental incentives to push actors to repair?
h. As a PRO actor, what is the primary benefit you gain from repairing or recycling phones?

Closing question: Are there other experts you recommend I conduct interviews with, and if yes, may you share their contacts with me?

B: Interview questions for Refurbishers/Repairers/Remanufacturers and Recyclers

Opening statement: Thank you for agreeing to be part of my interviews for my master's thesis. I am excited to speak with you because there is so much you know I could learn from. Before we begin, are you comfortable with me recording this interview? I would be the only individual who will hear/see it, and it will be used strictly for note taking and data analysis only. In addition will not share the file with other individuals.

The SE WEEE system - Based on RQ1

1. How does your company **operate** in the Swedish electronics **repair**/**recycling** market? What is your primary role in a simplified statement?
2. What are the challenges and difficulties within Sweden's WEEE system?
   a. What are **good features** of the Swedish WEEE system that allow it to be successful?
   b. What are some **negative features** of the system that prevent successes?
3. What are some things that are **unique** to how cellphones as an electronics group are managed within the Swedish WEEE system?
4. Recycling vs Repair
   The Swedish law supports recycling. The objectives of PROs are towards recycling. The push for repair is largely outside the legal framework, as recycling is the law.

   a. **As a recycler**, how are you integrating the push towards working in repair, despite being contractually obligated to recycling electronics?
   b. **As a remanufacturer**, how is this environmental pressure beneficial/harmful towards making actors work in repair?
5. Recycling vs Repair

    a. **For remanufacturers**: Is the current system **working well** in managing and elevating cellphone repair?

    b. **For recyclers**: Is the current system **working well** in supporting recycling cellphones?

Actors - Based on RQ3

6. Recycling vs repair
   a. Can you list the actors involved in **phone repair** in Sweden?
   b. Can you list the actors involved in **phone recycling** in Sweden?
7. *What kind of actor would you define your company to be according to this list?*
   Source: (Rizos et al., 2019; Svensson et al., 2018; Watson et al., 2017)

   - OEMS/Producers
   - Refurbishment/repair businesses
   - Consumers
   - Small unauthorized repair businesses
   - Network service providers
   - Secondhand sellers

8. As an **[type]** actor per Q7 above, do you have legal obligations to repair or recycle phones? What are they?
   a. If yes, are there conflicts between <u>the law</u> and <u>your business</u> when it comes to repairing and recycling phones in your industry?
9. If it is, how is the recycling regime a barrier to phone repair? If not, how so?
   a. **[If they are in repair also ask]** What drives unnecessary cellphone recycling in Sweden?
   b. **[If they are in recycling also ask]** Given you are in business to recycle, is this an incentive to maintain/push the recycling regime, even where it is less circular to do so?
10. What are the problems in an actor transitioning their services from recycling to reuse/repair (logistics, culture, market etc.)?
    a. **[If they are in repair]** – Do you see more actors in the future supporting repair? What would push the industry towards repair? How do we prevent regression towards unnecessary recycling?
    b. **[If they are in recycling]** – Do you see your company going into repair? What would need to happen for this to occur? What would need to happen for this to not occur?
11. What are the opportunities in **repair**/**recycling** cellphones?

Benefits - Based on RQ2

12. What are some of the benefits these actors you listed gain when they **repair cellphones**?
    a. Can you list some economic, social, and environmental benefits?
    b. Are there costs or forfeited benefits when actors choose to **repair**?
    c. Does the system have the legal/social/environmental incentives to push actors to **repair**?

      d. As a [**type**] actor, what is the primary benefit gained from **repairing** phones?

13. What are some of the benefits these actors you listed gain when they **recycle cellphones**?

      a. Can you list some economic, social, and environmental benefits?

      b. Are there costs or forfeited benefits when actors choose to **recycle**?

      c. Does the system have the legal/social/environmental incentives to push actors to **recycle**?

      d. As a [**type**] actor, what is the primary benefit gained from **recycling** phones?

Closing question: Are there other experts you recommend I conduct interviews with, and if yes, may you share their contacts with me?

C: Interview questions for Researchers/Other Stakeholders

Opening statement: Thank you for agreeing to be part of my interviews for my master's thesis. I am excited to speak with you because there is so much you know I could learn from. Before we begin, are you comfortable with me recording this interview? I would be the only individual who will hear/see it, and it will be used strictly for note taking and data analysis only. In addition will not share the file with other individuals.

The SE WEEE system - Based on RQ1

1. What are the challenges and difficulties within Sweden's WEEE system?

      a. What are **good features** of the Swedish WEEE system that allow it to be successful?

      b. What are some **negative features** of the system that prevent successes?

2. What are some things that are **unique** to how cellphones as an electronics group are managed within the Swedish WEEE system?

3. Recycling vs Repair

    The Swedish law supports recycling. Some actors like PROs are contractually obligated to the recycle regime. The push for repair is largely outside the legal framework, as recycling is the law.

      a. **How can recyclers** integrate the push towards working in repair, despite being (sometimes contractually) obligated to recycling electronics?

      b. **For remanufacturers,** is this environmental pressure beneficial/harmful towards making actors work in repair?

4. What changes in the current system will instead decrease the recycling of viable cellphones and elevate cellphone repair/remanufacturing?

Actors - Based on RQ3

5. Recycling vs repair

      a. Can you list the actors involved in **phone repair** in Sweden?

      b. Can you list the actors involved in **phone recycling** in Sweden?

6. In your research, how are actors navigating conflicts of interest in the repair/recycle debate? For example, cases where actors have targets for collecting WEEE for recycling vs push towards repairing viable cellphones.

7. If it is, how is the recycling regime a barrier to phone repair? If not, how so?

8. What incentives do **recyclers** have to maintain the recycling regime?

9. What incentives do **repairers** have to push the repair regime?

10. What are the problems in an actor transitioning their services from recycling to reuse/repair (logistics, culture, market etc.)?

11. As a researcher, do you see more actors making this transition from recycling to repair in future?

Benefits - Based on RQ2

12. What are some of the benefits these actors you listed gain when they **repair cellphones**?

      a. Can you list some economic, social, and environmental benefits?

      b. Are there costs or forfeited benefits when actors choose to repair?

      c. Does the system have the legal/social/environmental incentives to push actors to repair?

13. What are some of the benefits these actors you listed gain when they **recycle cellphones**?

      a. Can you list some economic, social, and environmental benefits?

      b. Are there costs or forfeited benefits when actors choose to recycle?

      c. Does the system have the legal/social/environmental incentives to push actors to repair?

Closing question: Are there other experts you recommend I conduct interviews with, and if yes, may you share their contacts with me?

Appendix 2: NVivo codebook

Name	Description	Files	References
Facts and Figures	Any interesting quotes or numbers go here	6	8
RQ1 - Cellphone uniqueness	Unique things about cellphones as an electronics group	9	60
RQ1 - Difficulties encountered pushing for cellphone repair	What actors find hard about phone repair	2	14
RQ1 - Future solutions and Innovative system changes	Hopeful solutions and innovations	0	0
Solutions - An all-actors approach to waste management	Solution type	1	1
Solutions - Collaboration and Communication	Solution type	8	14
Solutions - Device-as-service	Solution type	1	4
Solutions - Different business models	Solution type	6	15
Solutions - Digitalisation	Solution type	1	1
Solutions - Grading of e-waste	Solution type	1	2
Solutions - Legislation and Policy	Solution type	4	4
Solutions - Pant system for phones	Solution type	2	2
Solutions - Socialisation	Solution type	3	5
Solutions - The importance of design	Solution type	6	18
Solutions - Traceability system	Solution type	2	5
RQ1 - Good Features of Sweden's WEEE system	The good features that allow Sweden's WEEE system to be successful	5	18
RQ1 - How actors obliged to recycle are working towards repair	How are actors limited by law or agreements to recycling working in repairing	2	9
RQ1 - Negative features of Sweden's WEEE system	Bad features that cause problems	7	40

Name	Description	Files	References
RQ1 - Pressuring recyclers to repair	Things pushing recyclers to repair	3	7
RQ1 - Role of Various Actors in Swedish WEEE system	Role of various actors in SE WEEE system in phone repair	0	0
Role of Associations	Role of actor type	1	1
Role of consumers	Role of actor type	4	8
Role of EU government	Role of actor type	2	2
Role of Municipalities	Role of actor type	3	7
Role of national government	Role of actor type	3	3
Role of network service providers	Role of actor type	1	2
Role of pre-treatment companies	Role of actor type	1	1
Role of Producers	Role of actor type	5	9
Evolving role of producers	Role of actor type changing	6	14
Role of PROs	Role of actor type	4	19
PRO - Role evolution in system transition	Role of actor type changing	3	18
Role of Recyclers	Role of actor type	5	11
Role evolution - recyclers	Role of actor type changing	3	7
Role of refineries	Role of actor type	3	3
Role of Repairers	Role of actor type	8	21
Role of researchers	Role of actor type	3	5
Role of retailers	Role of actor type	4	9
Role evolution - retailers	Role of actor type changing	1	8
Role of storage companies	Role of actor type	2	3

Name	Description	Files	References
Role of transporters	Role of actor type	2	2
Role of Waste-to-Energy companies	Role of actor type	1	5
RQ2 - Recycle Benefits	Good things actors get from recycling	0	0
Recycle Benefit - economic	Anything to do with money	3	6
Recycle benefit - environmental	Environmental reasons	3	4
Recycle benefit - social	Society, relationships between actors, etc.	2	2
RQ2 - Recycle Costs	--	0	0
Recycle Cost - economic	Anything to do with money	7	26
Recycle Cost - legal	Legal factors	1	1
Recycle Cost - social	Society, relationships between actors, etc.	3	4
RQ2 - Recycle Incentives	--	0	0
Recycle Incentive - economic	Anything to do with money	8	21
Recycle Incentive - environmental	Environmental factors	6	13
Recycle Incentive - legal	Legal factors	5	15
Recycle incentive - social	Society, relationships between actors, etc.	4	5
RQ2 - Repair Benefits	--	0	0
Repair Benefit - economic	Anything to do with money	9	27
Repair Benefit - environmental	Environmental factors	8	16
Repair benefit - legal	Legal factors	1	4
Repair Benefit - social	Society, relationships between actors, etc.	4	5
RQ2 - Repair Costs	--	0	0
Repair Cost - economic	Anything to do with money	8	42

Name	Description	Files	References
Repair cost - environmental	Environmental factors	4	7
Repair Cost - legal	Legal factors	6	10
Repair Cost - social	Society, relationships between actors, etc.	6	11
RQ2 - Repair Incentives	--	0	0
Repair Incentive - economic	Anything to do with money	9	41
Repair Incentive - environmental	Environmental factors	9	24
Repair Incentive - social	Society, relationships between actors, etc.	7	24
Repair Incentives - legal	Legal factors	5	30
RQ3 - Barriers and Conflicts	--	0	0
Barriers and conflicts to the recycle-to-repair transition	Things that get in the way of society transforming to a repair regime	0	0
A business case for repair is critical, it must be economically viable	--see code title	4	14
Actors prioritising linear consumption	--see code title	6	11
Collection system does not facilitate repair	--see code title	3	3
Legislation doesn't facilitate nor make repair mandatory	--see code title	6	17
More collaboration and communication needed between WEEE actors	--see code title	5	6
Producers are not designing phones to allow repair	--see code title	4	7
Social perception of repair among WEEE actors	--see code title	7	23

Name	Description	Files	References
Technology not established repair and Difficulty with repair logistics	--see code title	5	17
SYNTHESIS MATRIX ANALYSIS TEXT	Any analytical text I made in the synthesis matrixes	6	41

Appendix 3: Sample from Synthesis Matrixes

Below is a partial screenshot taken from one of the multiple synthesis matrixes. This is to give an example of the layout used for the tool.