Transitioning towards a circular economy at an electronics manufacturer: Barriers and solutions for implementing a take back system in the US

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Abstract

So far, over 50 million tonnes of e-waste have been generated globally (World Economic Forum, 2019), raising the question of the role of circular economy in combating climate change (Ellen MacArthur Foundation, 2021). This thesis explores the opportunities for Axis Communications to introduce a take back system for recycling decommissioned products in the US.

Within this scope, several areas are investigated. Firstly, possible barriers for electronics manufacturers when establishing a take back system are reviewed, including how to overcome these barriers. Secondly, potential barriers for stakeholders in the downstream supply chain to participate in the system are examined, along with possible ways to incentivize them to join the take back system. Finally, a set of next steps are outlined for Axis to proceed with establishing a take back system.

These questions were answered by a literature review in combination with interviews and workshops. The insights from interviews were compiled into a visualization of clustered barriers, to get an overview of all barriers for an electronics manufacturer to establish a take back system. Next, a Solution Evaluation Matrix was developed, where potential solutions to each barrier were evaluated, based on the electronics manufacturer's capacity (ability and willingness) to execute them and the impact on the implementation. The thesis culminates in a roadmap for Axis, including a set of recommended next steps of how to move forward with implementing a take back system.

In conclusion, the thesis contributes to academic research, by addressing incentivization from a company to another, and to electronics manufacturers' practical implementation of a take back system.

Keywords: circular economy, e-waste take back, stakeholder barriers, B2B incentivization, solution prioritization

Sammanfattning

Hittills har över 50 miljoner ton e-avfall genererats globalt (World Economic Forum, 2019), vilket väcker frågan om den cirkulära ekonomins roll i kampen mot klimatförändringarna (Ellen MacArthur Foundation, 2021). I detta examensarbete undersöks möjligheterna för Axis Communications att införa ett system i USA för att ta tillbaka produkter som tagits ur bruk och återvinna dem.

Inom detta område undersöks flera aspekter. Först granskas möjliga hinder för elektroniktillverkare vid införandet av ett retursystem, samt hur dessa hinder kan övervinnas. Sedan undersöks potentiella utmaningar för intressenter inom försörjningskedjan nedströms att delta i systemet, samt möjliga sätt att ge dem incitament för att göra detta. Slutligen beskrivs nästa steg för Axis när det kommer till att införa ett system för återtag av gamla produkter.

Dessa frågor har besvarats genom en litteraturstudie i kombination med intervjuer och workshops. Insikterna från intervjuerna sammanställdes till en visualisering av klustrade barriärer, för att få en helhetsbild över alla barriärer för en elektroniktillverkare att implementera ett retursystem. Därefter utvecklades en matris för att utvärdera lösningarna. Potentiella lösningar för alla elektroniktillverkarens barriärer utvärderades utifrån företagets kapacitet att genomföra lösningarna, dvs. deras förmåga och vilja, samt lösningarnas påverkan på implementationen. Examensarbetet mynnar ut i en färdplan för Axis, samt rekommenderade nästa steg för hur man ska gå vidare med att införa ett retursystem.

Sammanfattningsvis bidrar examensarbetet till akademisk forskning, genom att belysa hur företag kan ge incitament till andra företag, och till elektroniktillverkares praktiska implementering av ett retursystem.

Nyckelord: cirkulär ekonomi, återtag av e-avfall, aktörers barriärer, B2B incitament, prioritering av lösningar

Acknowledgments

This thesis was conducted at Lund University at the Faculty of Engineering at the department of Design Sciences in collaboration with Axis Communications in Lund. Both parties have provided invaluable support and insights, and the authors' gratitude will be expressed below.

Firstly, we want to thank Ausra Reinap, supervisor at Axis, for your tireless support, positive spirit and passion to contribute to making this world a better place for all of us. Also, Nick Pintaro and Carl Trotzig at Axis deserve a special mention for their support and cooperation during the last couple of months.

Secondly, our supervisor at the university Kajsa Ahlgren-Ode has with her calmness and expertise been of great assistance. The feedback you have given has been priceless and with your humor, every meeting was very enjoyable and encouraging.

Lastly, we want to thank all the people contributing to our thesis by participating in our interviews, both internally at Axis and externally, giving us highly valuable insights. In conclusion, we are proud to present our thesis, but want to highlight that it would not have been possible without the support of many around us.

Lund, January 2022

Ebba Lundgren and Ellen Pellosniemi

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1 Introduction

In the introduction, the background to the problem will be given, thereafter the case company will be presented, and the problem closely described. Finally, the focus of the thesis including the delimitations, the target audience, and the structure of the thesis will be introduced.

1.1 Background

Climate change is a severe threat, resulting in tremendous consequences for both the environment and humanity. Scarce resources are being exploited in combination with the planet being heated up at a speed never seen before. This is an alarming and potentially irreversible development caused by human action (IPCC, 2018). Climate change can be slowed down by introducing circular economy practices in society (Ellen MacArthur Foundation, 2021).

There are multiple definitions in use for circular economy. Two widely accepted and popular ones are ‘an economy based on a “spiral-loop system” that minimizes matter, energy-flow and environmental deterioration without restricting economic growth or social and technical progress' (Geng et al., 2008) and ‘the circular (closed) flow of materials and the use of raw materials and energy through multiple phases' (Franklin-Johnson, Figge, & Canning, 2016).

Eventually, we will run out of critical resources and cause major health issues as a result of a lack of circularity in our current economy (World Economic Forum, 2019). Especially waste of electrical and electronic equipment, called e-waste or WEEE, is a substantial part of the problem, as it is globally the fastest growing waste stream (Forti et al., 2020). According to the World Economic Forum (2019), 48.5 million tonnes of e-waste had been generated worldwide up until 2018. By 2030 the global volume of generated e-waste is estimated to exceed 74 million tonnes (Andeobu, Wibowo & Grandhi, 2021).

Research shows that only 15-20% of the e-waste is formally recycled globally, and what happens to the rest is unclear (World Economic Forum, 2019; Andeobu, Wibowo and Grandhi, 2021). Considering the fact that e-waste contains material with a value of at least 62.5 billion US Dollars every year, the potential for recycling is substantial (World Economic Forum, 2019).

One way of introducing circularity in society is to implement closed loop systems (Schroeder, Anggraeni & Weber, 2018). However, there are challenges with these systems due to increased costs. Studies show that transportation cost is a major cost driver in reverse logistics networks (Safdar et al., 2020). Since transportation alone contributes to a large share of the costs, the need for an efficient circular supply chain is essential for a company to even consider moving towards circularity.

The United Nations has 17 sustainable development goals (SDG) to improve welfare, equality, and sustainability in the world (United Nations, 2021). Implementing circular economy practices is an effective tool for reaching a number of the SDGs. Schroeder, Anggraeni, and Weber (2018) have identified a direct correlation between circular economy practices and several SDGs, for example, SDG 12. Goal number 12, responsible consumption and production, is a part of the UN's call for action to fight climate change and resource scarcity (United Nations, 2021). However, Schroeder, Anggraeni, and Weber (2018) explain that progress in certain SDGs is required before successful implementation of some circular economy practices can be ensured. SDG 4 (Quality Education) is one of these goals that can support the implementation of a circular economy.

Legislation regarding e-waste management varies among the world's different countries. For example, in the European Union the WEEE directive is implemented to regulate the handling of e-waste, while national legislation on e-waste management in the US is nonexistent, leaving it for companies to decide how to handle their waste (Patil & Ramakrishna, 2020). The Basel Convention is the only international treaty on reducing the movement of hazardous waste worldwide, particularly movement from more to less developed countries. As of today, this UN treaty is signed, but not ratified by the United States (Patil & Ramakrishna, 2020). Out of the 187 participating countries, only the US and Haiti have not ratified the agreement (United Nations Treaty Collection, 2012). This thesis will address challenges with product take back of electronics with the objective of going to recycling, targeting the US market for a case company, Axis Communications, presented below.

1.2 Axis Communications

1.2.1 **Company description**

Axis Communications AB (below Axis) was founded in 1984 in Lund by Mikael Karlsson, Martin Gren and Keith Bloodworth. The company started by offering network printers and scanner servers. In 1996, their first network camera was launched, and today Axis is a global player within the surveillance network industry. Later, in 2015 Axis became a part of the Canon group. (Axis Communications,

2021a) Axis is a global player with customers all over the world. They have divided the world into 3 subregions, Americas (INC), Europe Middle East and Africa (EMEA), and Asia and the Pacific (APAC) of which INC is the biggest market, accounting for 57% of the income. The net sales globally in 2020 were almost 11,6 billion SEK. (Axis Communications, 2021b)

Supporting their vision “For a smarter and safer world”, Axis offers its customers solutions for video surveillance, access control, and speaker solutions (Axis Communications, 2021c). As cyber security has increased in importance, they now also support their customers with risk assessment and risk management (Axis Communications, 2021a).

Axis considers their downstream supply chain (see Figure 1) as a central part of understanding their business model (Axis Communications, 2021c). C. Trotzig, Director of Quality & Environment at Axis (personal communication, 9 September 2021), emphasizes that partnerships built upon loyal relationships are highly esteemed at Axis. He further highlights that Axis shows loyalty to their partners by never skipping a step in their downstream supply chain. Close collaboration with their partners is a vital part of Axis' identity.

Hereafter, the authors of the thesis have decided to use downstream supply chain partners for grouping distributors and system integrators, as they are seen as partners to Axis. Resellers are excluded in this thesis, since they account for such a small part of the sales. Additionally, downstream supply chain stakeholders include Axis’ end customers as well. Further, stakeholders and downstream supply chain stakeholders will be used interchangeably.

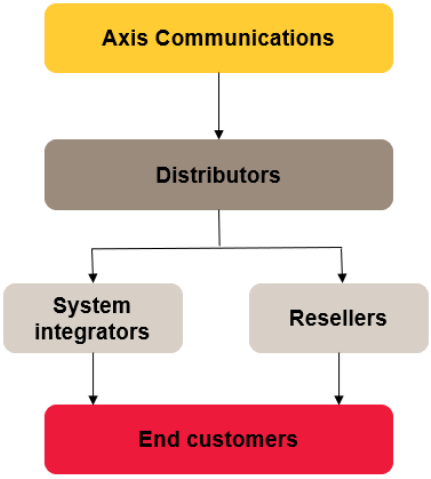

Figure 1. Axis' downstream supply chain

1.2.2 **An overview of environmental sustainability**

According to the CEO, Ray Mauritsson, Axis wants to act as a role model for other stakeholders in the market when it comes to sustainability (Axis Communications, 2019). In Axis' Annual Review and Sustainable Report 2020 (2021b), they state the importance of sustainability work in the company and that this should be reflected in their corporate strategy. Different initiatives show their efforts striving for these goals.

In 2007 Axis became a participant of the United Nations Global Compact (Axis Communications, 2021a), which is an initiative helping companies implement corporate strategies aligned with the UN goals (United Nations Global Compact, n.d.a). Signatories of the UN Global Compact should incorporate the UN Global Compact's ten principles. The principles are divided into four sub-areas: Human Rights, Labor, Environment and Anti-Corruption. (United Nations Global Compact, n.d.b)

According to Axis' Annual Review and Sustainable Report 2020 (2021b), they contribute to the sustainable development goals connected to the environment through three of their focus areas: Beat climate change, Protect natural resources, and Protect ecosystems. Each area has its own specific targets, to ensure measurable progress. The different targets can be seen in Figure 2.

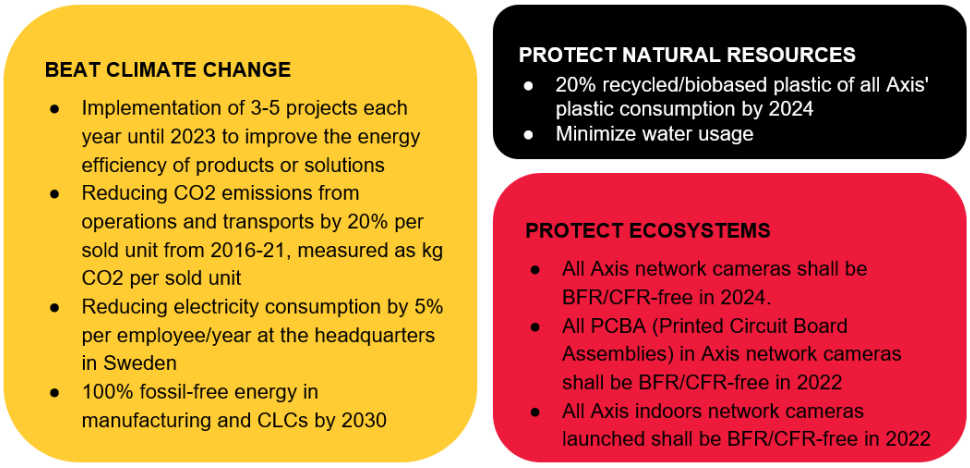

Figure 2. The case company's targets to achieve environmental sustainability (Axis Communications, 2021b).

Axis Communications is a forward-thinking company when it comes to sustainability and constantly striving to find new sustainable solutions. Within the context of protecting natural resources, recycling of their products is on the agenda.

1.3 Problem description

With critical resources running out and worries about Axis' environmental impact, the environmental team at Axis has identified the need of taking back products to close their supply chain loop. Nevertheless, they have no stated goal for their transition towards a circular economy, implying a weak top management support for circular initiatives. Today, the supply chain is linear and there are several intermediaries between Axis and their end customers, as seen in Figure 1. This long downstream supply chain, together with the fact that Axis does not own the products, are challenges for Axis to design a closed-loop supply chain.

One practical challenge associated with the take back setup, is the long downstream supply chain, entailing limited traceability, which affects the ability for Axis to locate the products to take back. Another challenge concerns the cost and the actual setup. Who shall collect the products and bring them to recycling, and who shall pay?

Contrary to the practical problems mentioned above, there are also challenges related to the end customers. Since the end customers have the ownership of the decommissioned products, Axis' ability to affect the end-of-life management is limited. Hence, Axis needs to convince their end customers that partaking in a take back system is beneficial. To find out how to motivate the end customers, it is necessary to understand the end customers' pains and gains.

Currently there is a lack of research investigating practical cases within this area, and thus there is a need for guidelines to other electronics manufacturers facing the same problem. The reverse flow of decommissioned products is critical for reaching circularity.

1.4 Purpose and Research Questions

The aim of this thesis is to investigate what barriers to be tackled for electronics manufacturers when introducing a take back system for decommissioned products in the US. Furthermore, the thesis shall examine solutions and outline a roadmap for establishing a take back setup.

The investigated research questions are:

RQ1: What are the possible barriers when introducing a take back system for electronics manufacturers?

RQ2: What solutions can help an electronics manufacturer to overcome these barriers?

RQ3: How should Axis Communications proceed with establishing a take back system?

The contributions to the academia of this thesis are to, from a company perspective, map relevant barriers to implement a reverse supply chain. Currently, many papers focus on governmental incentives, but as there are none in the US, companies today cannot count on those. They must reverse their own supply chains on the existing terms on the market. For this, a framework to map barriers and prioritize solutions will be presented.

Additionally, this thesis contributes to Axis' work towards circularity, which at this stage means to establish a take back set up for recycling of their products in the US market. Starting the conversation with end customers and partners, as well as mapping their hopes and needs, will pave the way for a future take back system.

1.5 Focus and delimitations

This thesis focuses on the take back of decommissioned products in the US market. When the authors mention decommissioned products, they refer to Axis products. All these products are electronic components and will eventually end up as e-waste. On a broader spectrum, the aim is to evaluate how the ever-growing e-waste stream can be managed through circular supply chains. The goal is for companies within the electronics industry to have a solid foundation for how to prioritize the solutions for overcoming the identified barriers. This is done by examining one company within the industry, namely Axis.

The purpose of the investigated take back system is, at this stage, to recycle decommissioned electronics. Thereby, reuse and remanufacturing of products will not be considered, despite them being important aspects of the circular economy. Additionally, the thesis does not include considerations on external or other societal factors, such as lobbying for changing current legislation or paving the way for a change of attitudes among citizens. However, this does include starting a conversation with some relevant stakeholders such as suppliers and partners in the supply chain of Axis. The highlighted area in Figure 3 displays the focus areas of the thesis.

The term sustainability is a broad concept including both environmental, social and economic aspects, and this thesis focuses on environmental and economic sustainability. When the authors talk about sustainability throughout the report, they refer only to environmental sustainability and when referring to economic aspects this will be pointed out separately. Social aspects are excluded altogether.

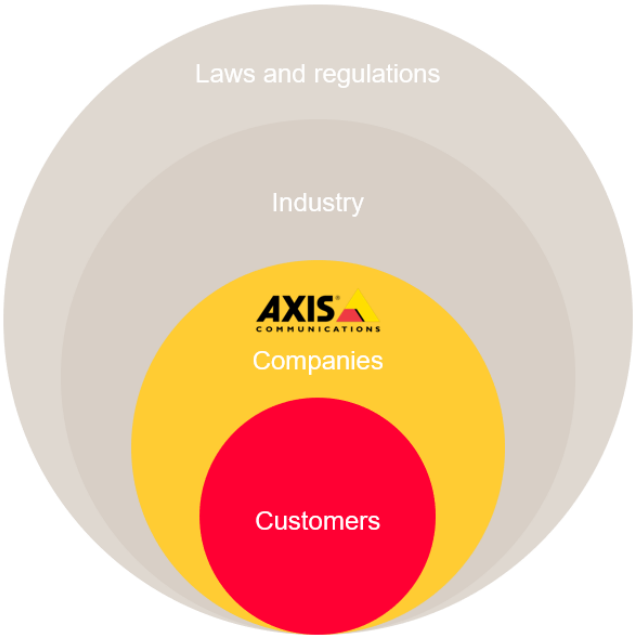

Figure 3. Focus is on barriers from a company perspective, where customers' attitudes have a big impact.

1.6 Target audience

The target audience for this thesis is stakeholders within the electronics industry aiming to understand what they can do to implement a reverse logistics setup. Additionally, the thesis is targeted towards researchers, academics and university students, who are interested in topics such as e-waste related circular economy and reverse supply chains.

1.7 Thesis outline

The thesis consists of seven separate chapters, outlined in Table 1 below.

Table 1. Summary of the focus chapter by chapter

Chapter	*Focus*
1. Introduction	Introducing the background and descriptions of the problem, including the research questions as well as Axis, the case company. Lastly, the focus and delimitations, target audience and the thesis outline will be presented.
2. Method	The chapter consists of firstly, the design of the research including literature review and data collection, secondly, the quality of research, and finally, the research ethics.
3. Theory	The theory comprises areas such as e-waste practices and legislation in the US, possible barriers for recycling of e-waste, stakeholder incentivization, as well as possible setups for reverse logistics.
4. Case Study	Here Axis, the case company, is presented in more detail, including their supply chain and current sustainability work. Further, a benchmark on circularity initiatives in the electronics industry is included.
5. Results	The chapter compiles the results from interviews with Axis' environmental team and internal experts, distributors, system integrators, end customers, and external experts.
6. Discussion	The chapter is discussing the gaps between research and practice, contributions to theory and practice, final recommendations for Axis, limitations of the research, as well as recommended future research.
7. Conclusion	The chapter is presenting the conclusion of the thesis.

2 Method

The method consists of the research approach and design, where the overall outline of the thesis process is defined. After this, the quality of the research is evaluated as well as the ethics of the researchers to ensure reliable results.

2.1 Research approach and method design

Höst, Regnell, and Runeson (2006) describe four extensive purposes for a master thesis. They are descriptive, exploratory, explanatory, and problem solving. This master thesis is both exploratory and problem solving. Further, this thesis examines a contemporary phenomenon, for which, according to Yin (2018), case study is a suitable method.

Yin (2018) presents two types of case studies, single-case study and multiple-case study. The purpose of this case study is to capture the circumstances and challenges connected to a take back system for recycling decommissioned products in one company. A single-case study is preferrable for a deeper understanding of a specific context and was, therefore, chosen for the thesis (Yin, 2018). Arguing that there were no logical subunits and that the theory underlying the case study was of a holistic nature, the holistic design was used. Consequently, the case study design is of Type 1, see Figure 4.

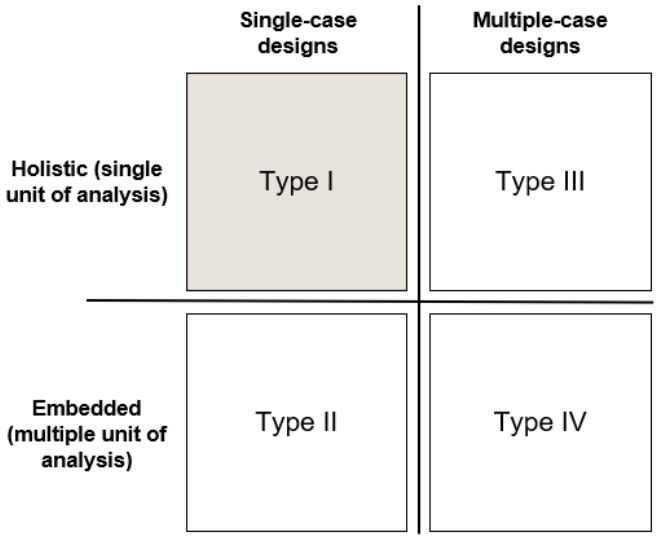

Figure 4. Designs for case studies (Yin, 2018), where type I is chosen for this study.

Yin claims that "...the design is the logical sequence that connects the empirical data to a study's initial questions and, ultimately, to its conclusions" (2018, p.26). Inspired by Yin (2018), the research steps are plan, design, prepare, collect, analyze, and share, see Figure 5. Each step will be explained in detail in the sections below. The steps prepare, collect, and analyze, have been conducted iteratively and are closely linked to one another.

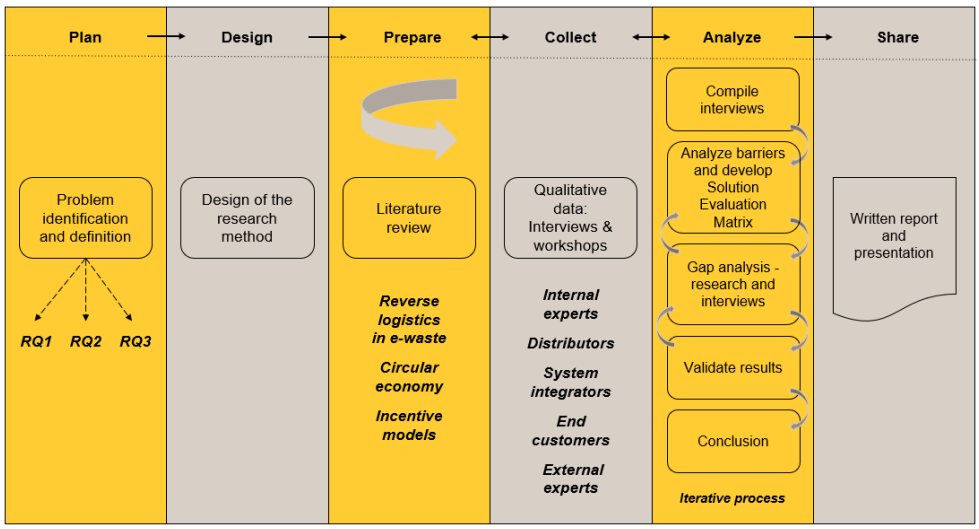

Figure 5. The research strategy for the thesis, inspired by Yin (2018).

2.1.1 Plan – Problem identification and definition

The authors were interested in the company Axis Communications, who had identified a problem connected to a potential take back setup for making sure decommissioned Axis products go to recycling. The authors thought that the subject fitted well with their Master Programs, one specialized in logistics and supply chain management and the other one in business and innovation.

Once the overall purpose was decided, the problem and appropriate research questions were defined together with Ausra Reinap, Senior Environmental Engineer and the authors' supervisor at Axis. This was finally verified by Kajsa Ahlgren Ode (supervisor at LTH) and Lars Bengtsson (examiner at LTH).

2.1.2 Design – Designing the process

The research design was framed after the problem was identified and defined. The comprehensive research process is described above in Section 2.1, and an overview is presented in Figure 5 in the same section.

2.1.3 Prepare – Literature review

In the third phase, the literature review is conducted inspired by the process used by Geissdoerfer, Vladimirova, and Evans (2018). A comprehensive literature review lays the foundation for later argumentation, which is why thorough work, and a good structure is essential. The process used is further explained below and can be seen in Figure 6 below.

A set of keywords were brainstormed and based on these the database Web of Science was used for searching the literature. The keywords included circular economy, e-waste, reverse logistics, incentive models, e-waste management, and circular value chain. These were used in different combinations for maximal output of relevant articles.

At this stage, relevant articles were filtered out based on the applicability of the abstract. In total, 75 relevant articles were found during the first round and added to a list. As the search for relevant literature was an iterative process, the final list was longer. More relevant articles were found through cross-referencing and snowballing.

After this, the relevance of the samples was determined and as a consequence, the list was narrowed down. First, all articles were studied more carefully and shortly summarized to be able to conclude if they were relevant (1), potentially relevant (2) or not relevant (3) articles for this paper. Only relevant and potentially relevant articles were kept on the list. The iterative process of finding relevant articles

continued as long as it was determined that relevant literature was missing. Finally, the entire sample was reviewed once more to guarantee relevance.

Throughout, more recently published literature was preferred over older articles, as the circular economy is a dynamic area where a lot of changes has been occurring recently. Consequently, articles published in 2015 or later were prioritized. The conducted literature review is presented in Chapter 3.

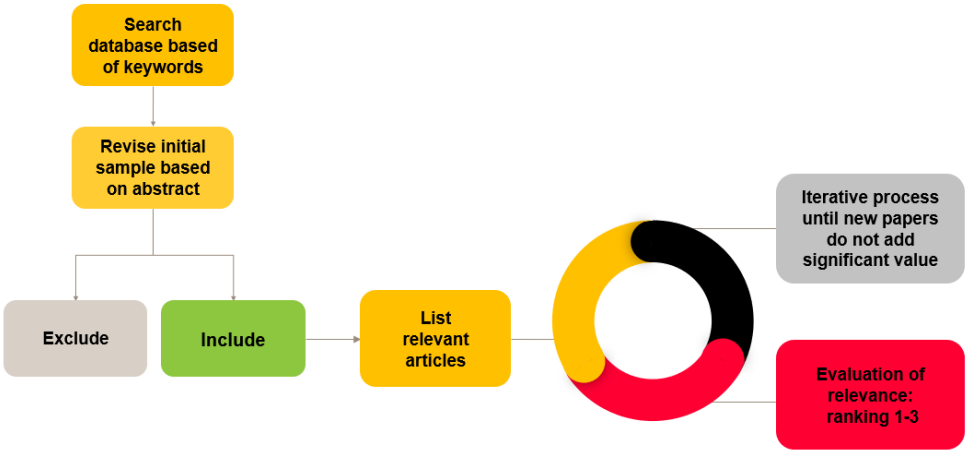

Figure 6. Outline of the literature review (Geissdoerfer, Vladimirova & Evans, 2018).

2.1.4 **Collect – Data collection**

This phase comprises the collection of qualitative data in the form of semi-structured interviews and interactive workshops. The overall interview process was first to determine who to interview, to develop the interview guides, to conduct said interviews, and finally to compile the interviews and prepare for thorough analysis.

These interviews were held with stakeholders in Axis' downstream supply chain, including distributors, system integrators, and end customers, in the US. An important part, in the beginning, was to determine a suitable sample size and who to interview (Höst, Regnell, & Runeson, 2006). In correspondence with US contact person, Nick Pintaro (2021), Program Manager for Key Accounts, it was discovered that system integrators account for around 97% of Axis' sales in the US. Hence, it was judged that interviews with them should be included while interviews with resellers should be excluded.

The authors tried to reach out to the biggest distributors, system integrators, and end customers as their potential participation in Axis' take back system would result in a larger environmental impact in comparison to smaller stakeholders' participation. Hereafter, a few companies per stakeholder group within the downstream supply chain in the US were chosen, to represent the group. A list of the interviewees can

be found in Appendix A.1. Further, to ensure that the interviewees met the selection criteria and thus that useful information could be obtained, appropriate filtering questions were developed for each stakeholder in the downstream supply chain. These questions were asked prior to the interview and can be found together with the interview guides, in Appendix A.2.

The aim of the interviews was to gather as much information as possible about the parameters influencing recycling choices. Therefore, the interviews were semi-structured with open-ended questions to allow the interviewee to give elaborate responses. The interviews were planned according to the structure recommended by Höst, Regnell, and Runeson (2006). This implies that the interviews started with an introduction, followed by comfort questions to get to know the interviewee, as well as the main part, and finally the conclusion. The main part consisted of questions on the evaluation of different alternatives for a take back system. Inspired by the literature and in collaboration with Ausra Reinap, Nick Pintaro, and Jenny Weeks, supervisors at Axis, the interview guides for the different stakeholders were formulated. All the full interview guides can be found in Appendix A.2.

Furthermore, iterative workshops were conducted with the environmental team at Axis' headquarter, in Sweden, as well as interviews with internal experts of the current reverse logistics organization and in the current partnership program, to gain insights of the case company's identified barriers. In addition, external experts, recycling service providers (RSPs), were interviewed to get a more profound understanding of possible barriers and solutions.

2.1.5 **Analyze – Analysis of collected data**

The analysis was an iterative two folded process. On one hand, analyzing and summarizing the result from interviews, and on the other hand, examining the differences and similarities between theory and practice.

In the first step, all the data collected in the interviews were compiled. In parallel the barriers were clustered according to found patterns. Further, a Solution Evaluation Matrix was developed with inspiration from theory, to be able to evaluate the suggested solutions gathered from interviews and workshops. This process was iterative, and several discussions were needed with the researchers and supervisors. Common denominators in interviews for each stakeholder group were highlighted, as well as the differences within the said groups. These patterns were used as a basis for discussion, however, no wider statistical conclusions can be drawn as the sample size is small. Lastly, a roadmap was outlined for the case company establishing a take back system including the needed setup and stakeholder incentivization considerations.

The final results were then validated by industry experts. This triangulation was done together with the Operations Manager at Axis in the US, and two recycling service providers in the US.

In the next step, a gap analysis was conducted by comparing the literature with practice. The intellectual exchange between academia and practice, through the case company, is important to evaluate the feasibility of existing research. The interviews were audited to find patterns in the answers and to analyze this in relation to existing literature.

2.1.6 **Share – Compile report and presentation**

In the last step of the research process, the report is finalized, which includes compiling the report, finalizing conclusions and critically reviewing the report. The latter is done throughout the process by multiple parties to ensure high quality.

Lastly, the presentations are given at Axis Communications and Lund University separately, and the report is then revised based on feedback from the company, the examiner at the university and fellow students.

2.2 Quality of research

Lincoln and Guba (1985) introduced four aspects for defining and investigating the quality of qualitative research. These concepts are credibility, transferability, dependability, and confirmability, and are analyzed separately below. In addition, reflexivity was included to address self-reflection (Korstjens & Moser, 2017). These aspects evaluate the overall trustworthiness of the thesis, but also specifically the quality of used data and methods used to analyze said data.

The *credibility* of the research determines if both community members and participants feel like the results match their experience. The credibility of research can be ensured, for example, by triangulation. In this thesis, an interview with industry experts was conducted to validate the findings. Additionally, multiple viewpoints were considered by interviews with several stakeholders in Axis' downstream supply chain. Both contribute to the credibility of the research and are ways of triangulating data.

Transferability refers to how relevant and applicable the results are in a broader context, beyond the specific study. In this thesis, a limitation is the transferability to other companies within the e-waste heavy industries, as this thesis only examines one company, Axis. The stakeholders in Axis' downstream supply chain can hardly be seen as representing the whole electronics industry, due to the few numbers of interviews from each stakeholder group. Furthermore, the geographical

delimitations, the US market, also means fewer possibilities for worldwide conclusions. However, the studied case company gave indications of potential barriers and a generalized framework, to map barriers and prioritize solutions, was developed for the electronics industry, aiming for a sufficient level of transferability.

Dependability recognizes the fact that findings should be consistent over time, as the results need to be repeatable and consistent. Proper documentation is necessary for this. This can be assured by external auditing, which in this case is done by feedback and public discussion and examination of the thesis by other students.

Confirmability states that the findings cannot be affected by the biases of the researcher. The findings should not differ if the study was conducted by another researcher. Within this thesis, this has been managed by regular checks by the supervisors, a form of triangulation. This was to make sure that findings are based on data from interviews and literature, and not altered by the biases of the researchers.

Reflexivity refers to the process of critical self-reflection. Researchers must question their own biases, preferences and preconceptions, but also their relationships to the case company and interviewees. To tackle this, interactive sessions between the two researchers have been held to discuss said topics and reflect on them.

2.3 Research ethics

During the master thesis, two main ethics considerations, bias, and integrity, was discussed and examined. According to Yin (2018), researchers must actively avoid bias. Continuous external reviews throughout the thesis are essential to avoid researchers' biases. Within the thesis, this is completed through weekly meetings with supervisors at the University and Axis Communications, as well as a continuous review of the written report by both supervisors.

Additionally, researchers must protect the integrity of the parties involved in three ways (Yin, 2018). Firstly, participation in research should be voluntary, therefore consent from the participants to be included in the research is necessary. Secondly, the privacy and confidentiality of participants should be respected, matching the participants' requested level of discretion. Lastly, authors must refrain from all kinds of dishonesty, particularly in the data collection stages. This will be accomplished by ensuring voluntary participation in interviews, by explicitly asking about the desired level of anonymity, and by the authors' peer-reviewing of one another.

3 Theory

The chapter begins with some general principles of circular economy and the overall scene for e-waste in the US, including related legislation in the country. Afterwards, guidelines for how to set up a take back system, barriers to do so and how to incentivize partners and customers to collaborate, are addressed.

3.1 Principles of circular economy

A well-known model within the sphere of circular economy is the 3Rs, seen to the left in Figure 7. This model consists of three pillars namely reduce, reuse and recycle. This exemplifies what kind of treatment is the most beneficial for the generated waste, and thereby the order of the steps of effectively reaching circularity. The first priority is to reduce the used material, followed by reuse, and lastly recycle. The model has existed for approximately 40 years and originates in the US from the company 3M and in Europe from the work of the Dutch politician Ad Lansink, who presented it in the Dutch Parliament in 1979. (Pires & Martinho, 2019)

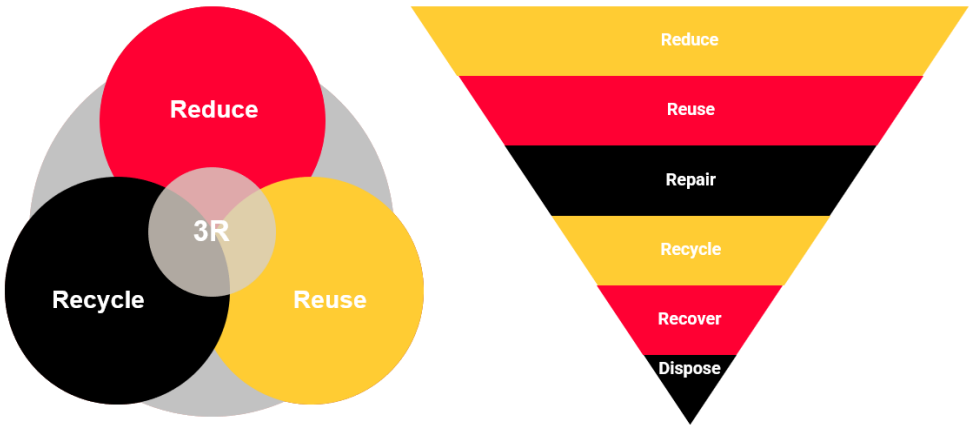

Figure 7. Waste handling models; 3R and waste hierarchy.

The waste hierarchy, to the right in Figure 7, also explains the preferable waste handling, but in more detail, adding 3 stages to the 3Rs. The first step refers to reducing the amount of used materials, which could be done by more efficient

design of the product and packaging, and by minimizing waste in production. The second step is about reusing products, and this also relates to the third step of repairing and remanufacturing products. These steps aim to prolong the lifetime of products. In the fourth stage, recycling of the materials in the products is suggested, which means reusing materials and components from old products. The fifth step is energy recovery from the materials, and the last stage is disposal of products when none of the earlier stages is possible to follow through with. The higher up in the hierarchy one is able to reduce waste, the better, both from an economic and an environmental point of view. (EU Commission, 2015)

In line with the reasoning above, the Ellen MacArthur Foundation (2021) has formulated two core principles of circular economy, namely designing out waste and keeping products and materials in use (see Figure 8). The latter one is divided into two parts. The Ellen MacArthur Foundation (2021) estimates the potential of annual global CO2 emission reductions from key industries[1], as a result of a circular economy, to approach 40% or 3.7 billion tonnes in the year of 2050.

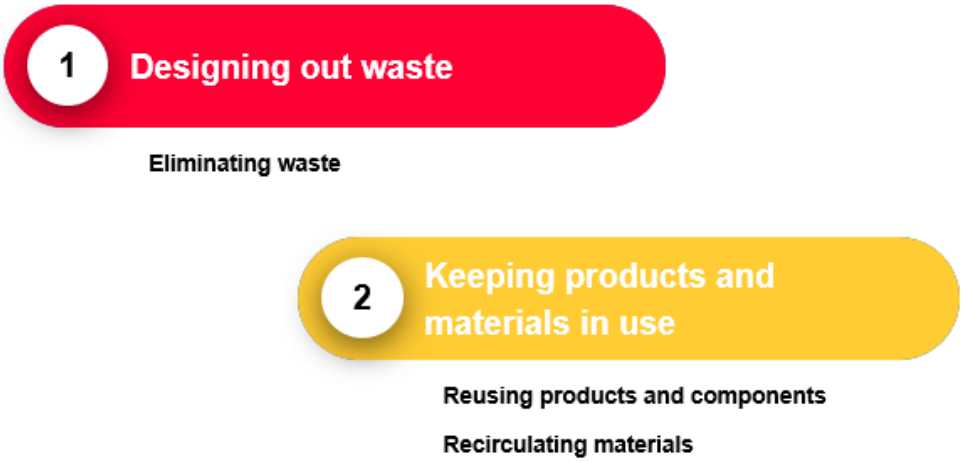

Figure 8. Principles of circular economy by the Ellen MacArthur Foundation (2021).

Designing products better leads to eliminating waste generation in the whole value chain. This involves using material designs requiring less material in buildings, industrializing construction processes, and designing with lighter material in vehicles. (Ellen MacArthur Foundation, 2021) However, this principle falls outside the scope of this thesis.

The principle of keeping products and materials in use is divided into two parts. The first part is reusing products and components, which means increasing the utilization rate by new service-business models, and creating processes for reuse,

[1] These key industries are steel, aluminum, plastics, and cement (Ellen MacArthur Foundation, 2021).

refurbishment, and remanufacturing. This reduces the need for new production and end-of-life treatment. (Ellen MacArthur Foundation, 2021) Also, this area is outside the scope of this thesis, however, a natural next step is looking at reuse after assessing recycling possibilities.

The second part is recirculating material, and this could potentially reduce the annual CO2 emissions by 1.7 billion tonnes in 2050, a momentary estimation for the year of 2050. Within recirculating material, business model innovation stimulating collection, sorting, and recycling activities are applied. With increased recycling rates and increased demand for recycled products, the development will accelerate and eventually economies of scale will make it more viable. These actions can reduce production and end-of-life treatment emissions since there would be a decreased use of virgin materials. (Ellen MacArthur Foundation, 2021)

This thesis primarily focuses on the principle of recirculating material in the Ellen MacArthur Foundation's principles of circular economy and the phase of recycling in the 3R and waste hierarchy models. Moreover, the thesis will discuss e-waste recycling in the US market, which will be addressed below.

3.2 An overview of e-waste in the US

The accelerated economic development in the United States has increased the demand for consumer goods. This leads to growing amounts of waste. Particularly fast growth has been seen in the industry for electrical and electronic equipment. One major issue, relating to this equipment, is said to be the traceability after reaching a state-approved collection agency. It is currently estimated that roughly 50–80% of the e-waste generated in America ends up in developing countries. The most pressing concerns are increasing health issues and the impact on the environment. (Andeobu, Wibowo & Grandhi, 2021)

According to calculations made by Powell and Chertow (2019), the landfill quantity of e-waste in the US is 3.5 million tonnes which is equivalent to the weight of 10 million fully loaded light trucks[2]. This is far greater than calculated previously by the US government. Considering the expenditures related to disposal, the cost of municipal solid waste landfill disposal in 2015 was estimated to be 10.7 billion US Dollars (Powell and Chertow, 2019). In the same year this would have accounted for around 2.3% of the gross domestic product (GDP) of the Washington Metropolitan area (Statista, 2021a), which is the 5th biggest metropolitan area in the US in terms of GDP (Statista, 2021b). The potentially recyclable material was estimated to be worth 1.4 billion US Dollars the same year (Powell and Chertow,

[2] A fully loaded light truck weights 3,500 kg (Transportstyrelsen, 2013)

2019). This suggests that there is a potential to reduce landfill costs and generate revenue by increased material recovery, which could potentially be done by introducing circularity.

As reported by the US Environmental Protection Agency (USEPA) roughly 142,000 computers and over 416,000 mobile phones are discarded annually, of which only 27% are being recycled (Andeobu, Wibowo & Grandhi, 2021). Despite there being possible revenues streams, recycling rates has yet to take off. One explanation could be that there are worries about the cost of proper recycling in comparison to the cost for disposal. These concerns relate to the cost of the waste collection, the processing, and the disposal of the waste, as well as the energy consumption during the recovery process. Today, costs are still higher than the generated revenue from recovered recycled materials. Data from 2015 show that recycling e-waste costs between 450 US Dollars and 1000 US Dollars per tonne. Considering that disposal into landfills cost between 150 US Dollars and 250 US Dollars, the difference is substantial. Later in 2017, it was estimated that the cost for recycling was higher than two years before, around 760 US Dollars per tonne, whereas for large volumes it was estimated to have decreased to around 550 US Dollars. (Andeobu, Wibowo & Grandhi, 2021; Yang, Sun, & Ni, 2021)

3.3 E-waste legislation in the US

With no ratification of the Basel Agreement and no national laws covering e-waste, the US has an issue when it comes to handling e-waste. Out of 52 states, 25 have implemented their own laws. However, since the laws are, as mentioned, not federal, they lack nationwide uniformity (Patil & Ramakrishna, 2020; Kumar, Holuszko & Espinosa, 2017). Additionally, the US is far behind in necessary e-waste infrastructure compared to other developed countries (Andeobu, Wibowo & Grandhi, 2021). Although some states have comprehensive e-waste regulations, others still permit the disposal of e-waste into landfill. Nevertheless, the tables are turning, and many states are now forbidding discarding e-waste into landfill (Khan et al., 2014).

In the US today, there are multiple initiatives connected to recycling, reuse and disposal of e-waste built upon the principle of Extended Producer Responsibility (EPR) (Khan et al., 2014). EPR is explained as a principle for environmental policy where the producer's responsibility is broadened and involves obligations to take care of products after consumers no longer want them. This covers for example providing product take back, recycling, and disposal. (OECD, n.d.) The main goal of the EPR strategy in the US is to minimize the amount of e-waste ending up in landfills or incinerators and simultaneously maintain producers' profitability (Khan et al., 2014). This can be done best by implementing the steps of the waste hierarchy (Khan et al., 2014; Afroz et al., 2013).

Unfortunately, the EPR strategy, implemented in some states, instead led to the export of e-waste to for example Mexico, China, and some African countries (Patil & Ramakrishna, 2020). This makes the waste untraceable and due to the informal treatment, the waste further pollutes the environment (ibid). There is no jurisdiction over foreign trade zones, which means that this export is, in fact, legal (ibid). To decrease this export to developing countries, a national law was passed in Congress. This law was passed in 2011 and is called "Responsible Electronic Recycling Act (HR2284) 2010" (Khan et al., 2014).

Currently, there are some measures for the management of nationwide e-waste for example through the Resource Conservation and Recovery Act (RCRA) (Patil & Ramakrishna, 2020). In addition, The National Strategy for Electronics Stewardship (NSES) is a federal framework for managing e-waste streams, initiated by US Environmental Protection Agency (USEPA) in collaboration with Council on Environmental Quality (CEQ) and General Services Administration (GSA). This framework brings together stakeholders from the electronics, retail, and recycling industries to discuss e-waste management (Andeobu, Wibowo & Grandhi, 2021; Shittu, Williams, & Shaw, 2021). Moreover, the USEPA has an initiative called Sustainable Materials Management (SMM) Electronics Challenge initiative where they partner up with Original Equipment Manufacturers (OEMs) and retailers. The idea is to take back and recycle used electronics via certified recyclers (Patil & Ramakrishna, 2020; Shittu, Williams, & Shaw, 2021).

In conclusion, there are numerous initiatives to address the problem of e-waste management in the US. However, as of today, there is no federal law covering this leading to the export of e-waste to developing countries (Patil & Ramakrishna, 2020).

3.4 Reverse logistics setups

There are several alternatives for how to set up a reverse logistics system, which for example, involves the considerations of transportation of collected waste and where to recycle it. Either the retailer, producer, recycler, or a third party can collect the e-waste (Zhang, Gang & Han, 2019). Depending on what the supply chain looks like, there can be other alternatives for stakeholders to collect the waste. Further research on different guidelines for setting up a take back system is presented below.

According to Safdar et al. (2020) the evaluation and reprocessing of recovered materials account for the biggest carbon emissions in the reverse supply chain. However, the greatest cost driver is the transportation between end customer and collection center and the one from recycling center to distribution centers. To minimize the cost of transportation, the location of the collection centers is, therefore, of great importance.

In addition to minimizing transportation costs, it is important to consider how to design the reverse logistics setup. Thus, Ghalehkhondabi and Ardjmand (2020) have investigated the equilibrium between government, e-waste recycler, and e-waste collector in a waste management supply chain. The e-waste recyclers in the observed supply chain sell the recovered valuable materials to electronics manufacturers. The e-waste is collected either by recyclers or collectors. In the study, the government participates by collecting taxes and emission penalties. Demand sensitivity of recovered e-waste material is another assumption within the study, which implies increased demand if the price is lower or if the sustainability level is higher. Considering these assumptions, it is concluded that a supply chain will benefit from centralized decision making between the collection center and the recycling center. This would reduce uncertainties thanks to improved information sharing. (Ghalehkhondabi & Ardjmand, 2020)

This result is strengthened by Min et al. (2005), who explain that integrated collaboration between firms increases the profit for the entire supply chain. However, the profit might not be visible directly for each stakeholder in the supply chain, which means that trust is one of the biggest challenges in collaboration (Ghalehkhondabi & Ardjmand, 2020; Min et al., 2005). Further, Flygansvaer, Dahlstrom, and Nygaard (2018) emphasize the benefits of collaboration for an increased level of satisfaction within the reverse supply chain. Ghalehkhondabi and Ardjmand (2020) also observed an increase in the supply chain profit when the collection center and the recycling center shared the collection activity. The risk of material shortages to the recycling center was reduced as a result of the shared collection activity.

In addition to profit benefits, the centralized approach in the e-waste recovery process will also lead to environmental sustainability advantages. Consequently, customers valuing environmental sustainability higher than the average will prefer this setup, and hence they are willing to pay a higher price. (Ghalehkhondabi & Ardjmand, 2020)

To sum up, different kinds of arrangements for the waste collection, but also the recycling, need to be considered, especially since transportation cost is the most substantial cost driver. Additionally, research recommends centralized decision making between the collection and recycling centers, and studies also show that unified collaboration increases joint profitability and increases environmental sustainability throughout the supply chain. A natural continuation of evaluating set ups is looking into barriers to establishing a take back system and these will be addressed below.

3.5 Barriers for e-waste reverse logistics

To fully comprehend how to accomplish a circular supply chain, it is important to understand the barriers. In this section, literature has been reviewed, in order to identify the challenges connected to a reverse logistics system and taking back products for recycling. From a company perspective, there are both external and internal barriers (Bressanelli, Perona & Saccani, 2019; Bressanelli et al., 2021; Govindan & Hasanagic, 2018; Julianelli et al., 2020; Khan, Haleem & Khan, 2020; Moktadir et al., 2020; Werning & Spinler, 2020). In this thesis, the governmental, societal, and individual consumer perspectives are excluded, due to the difficulty for an individual company to influence these.

The transition towards a circular economy within a firm is a complex process involving several barriers to overcome along the way. Werning and Spinler (2020) highlights the importance of prioritizing which barriers to focus on. Therefore, they have created a circular economy matrix as a tool for this. The axes of the matrix are organizational resistivity and impact on the value chain. Organizational resistivity includes expected financial resources, managerial time, and cultural resistance for each barrier. The impact on the value chain refers to the extent a certain barrier influences the material flow in the entire value chain. When these two values are evaluated for a certain barrier, they can be placed in the matrix (see Figure 9). The barriers placed in the red squares are high priority, the yellow squares are middle priority, and finally, the green squares are low priority. Another way to categorize barriers is dividing them into two groups, causes, and effects, and prioritizing the causes according to Khan, Haleem and Khan (2020). They suggest that the causes are the roots of the problem, leading to the effects, and should therefore be prioritized.

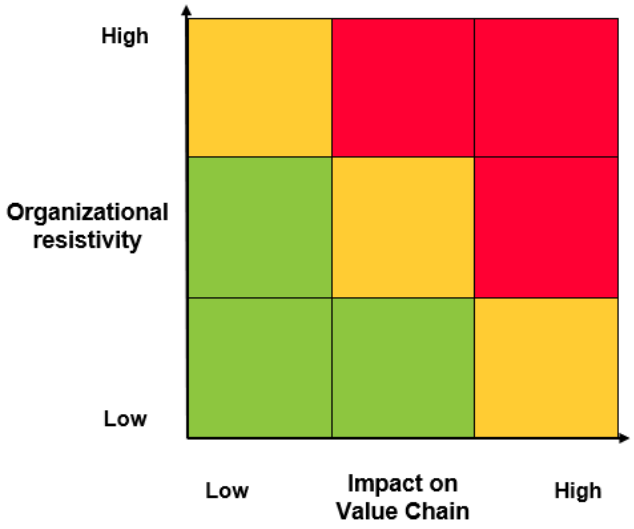

Figure 9. Circular economy matrix (Werning & Spinler, 2020).

Aside from prioritizing the barriers, it is important to assign the responsibility of each barrier for an effective transition to circularity. Due to the interconnection between barriers, it is important that low-priority barriers are not excluded, but rather analyzed to understand if and how it impacts a barrier with higher prioritization. (Werning & Spinler, 2020)

One activity to reach a circular economy is the implementation of a closed loop supply chain. To succeed with this implementation one vital factor is to create a seamless reverse supply chain, including the collection activity. It is important that the costs connected to the reverse logistics, collection and product handling do not remarkably exceed the low landfill cost. (Schroeder, Anggraeni & Weber, 2018) Further identified barriers within the literature are described below.

A substantial barrier, brought up by multiple reports, is the *corporate misalignment*, which in literature refers to lack of corporate decisions promoting circularity, general reluctance to create a circular long-term strategy and lack of top management support for circular initiatives. (Govindan & Hasanagic, 2018; Khan, Haleem & Khan, 2020; Moktadir et al., 2020; Werning & Spinler, 2020)

Another corporate and strategic barrier is the choice of *sales and business models* in a company since these will affect the ownership of the products (Bressanelli et al., 2021; Govindan & Hasanagic, 2018; Khan, Haleem & Khan, 2020; Werning & Spinler, 2020). Companies might not have any interest in taking ownership of their products throughout their life cycle, however this affects the control at the point of sale (ibid). When this control is low, and there is no ownership, it is hard to directly communicate and promote recycling of products at their end of life (ibid). Typically when a company does not maintain ownership, they lose the *possibilities to trace*

the products. This leads to less transparency and forecastability of the return flows (Khan, Haleem & Khan, 2020).

In addition to the sales and business models, a barrier of implementing a take back system is the *uncertain return on investment* (ROI). There is a mismatch between revenue and cost streams in time, since a take back system requires upfront investments while the revenue is paid back slowly, if at all. Moreover, with *inappropriate key performance indicators* (KPIs), not aligned with the purpose of the initiative, it is challenging to implement a reverse logistics organization. The traditional ones are typically aligned to achieve results within a linear supply chain, which is not desirable when implementing a take back system. (Bressanelli, Perona & Saccani, 2019; Govindan & Hasanagic, 2018)

Another challenge also affecting the ROI and KPIs is th*e cost associated with reverse logistics*. Related to a take back system, this means costs for recycling and transportation, as well as labor costs for planning and setting up the reverse logistics organization. (Bressanelli, Perona & Saccani, 2019; Govindan & Hasanagic, 2018; Julianelli et al., 2020; Werning & Spinler, 2020)

Furthermore, *limited experience within the field* makes it challenging to establish a take back system. This implies not only that there is a limited or no reverse logistics organization, but also that know-how on how to implement one is lacking. With no experience it is also difficult to guarantee reverse logistics stability due to volatility in return flows. (Bressanelli, Perona & Saccani, 2019; Bressanelli et al., 2021; Khan, Haleem & Khan, 2020; Moktadir et al., 2020; Werning & Spinler, 2020)

Further, there is a general *lack of knowledge* among the company itself, the stakeholders in the supply chain, and the customers when it comes to the potential of circular economy (Govindan & Hasanagic, 2018; Khan, Haleem & Khan, 2020; Moktadir et al., 2020; Werning & Spinler, 2020). The absence of reliable information on how to recycle e-waste, can be a reason to refrain from recycling (Govindan & Hasanagic, 2018).

Additionally, the *cultural issues* as a result of the currently widely spread *linear mindset* makes it harder to implement a circular supply chain (Bressanelli, Perona & Saccani, 2019; Govindan & Hasanagic, 2018). The linear mind-set is a barrier for both companies and their customers (Bressanelli, Perona & Saccani, 2019; Bressanelli et al., 2021; Govindan & Hasanagic, 2018; Khan, Haleem & Khan, 2020). For customers this will have an impact on what decisions they make at the point of sale, during usage of the product and at end of life (ibid).

Partially as a result of the linear mindset, there might also be a *fear of hurting the brand* when taking back decommissioned products. This could stem from the fact that the quality of the products or the perceived quality of products might be lower if recycled materials are used in products (Bressanelli, Perona & Saccani, 2019). Furthermore, literature discusses the barrier related to the *risk for cannibalization* if products are reused. It is argued that companies might fear implementing a take

back system for recycling as this could lead to cannibalization, when the initiative is taken to the next stage towards reuse, by remanufacturing and refurbishing (Bressanelli, Perona & Saccani, 2019; Werning & Spinler, 2020). As a consequence, the fear of what a take back system implies later on, should be addressed in organizations (ibid).

To establish a take back system different partners will be needed in some areas. To achieve a desired outcome *collaboration with supply chain partners* is important (Bressanelli, Perona, & Saccani, 2019; Julianelli et al., 2020). The goals and priorities need to be aligned for the cooperation to be successful (ibid). For this the coordination and information sharing become important (ibid). Additionally, the *reverse logistics infrastructure* needs to be set up (Bressanelli, Perona & Saccani, 2019; Govindan & Hasanagic; Khan, Haleem & Khan, 2020; Moktadir et al., 2020). To establish a functioning take back system it is essential to find trustworthy partners for recycling and transportation (ibid). The recycling partners need to be reliable so that customers can trust that their equipment is not misused at the end of their products' life (ibid). Trust between partners is the cornerstone for a fruitful collaboration, making it especially important to focus on (Ghalehkhondabi & Ardjmand, 2020).

Further, to enhance collaboration with partners, it is important to address the challenge of *required customer effort* (Bressanelli et al., 2021). It will demand time and effort from the company, implementing a take back system, to make the whole process seamless and easy for the customer. Customers will likely need *economic incentives* as an encouragement to take part in such a system (Khan, Haleem & Khan, 2020). In addition, the *cyber security challenge* needs to be overcome in order to implement a take back system (Bressanelli, Perona & Saccani, 2019).

To summarize, multiple barriers make it challenging to implement a take back system. These are summarized in Table 2, and worth noticing is that challenges connected to the company are more common in literature than challenges addressed for the end customers to participate in a take back system. To overcome the challenges, appropriate prioritization is essential to transform the previous barriers into critical success factors instead.

Table 2. Challenges identified with take back for recycling in literature.

Company	***Literature***
Corporate misalignment due to lack of lack of top management support for circular initiatives	(Khan, Haleem & Khan, 2020); (Moktadir et al., 2020); (Govindan & Hasanagic, 2018); (Werning & Spinler, 2020)
Sales and business model determining ownership of products	(Khan, Haleem & Khan, 2020); (Govindan & Hasanagic, 2018) (Spinler, & Werning, 2020); (Bressanelli et al., 2021)
Possibilities to trace products	(Khan, Haleem & Khan, 2020)

Uncertain ROI due to mismatch between costs and revenue	(Bressanelli, Perona & Saccani, 2019); (Govindan & Hasanagic, 2018)
Inappropriate KPI not supporting environmental initiatives	(Bressanelli, Perona & Saccani, 2019); (Govindan & Hasanagic, 2018)
Costs associated with reverse logistics	(Werning & Spinler, 2020); (Julianelli et al., 2020); (Govindan & Hasanagic, 2018); (Bressanelli, Perona & Saccani, 2019)
Experience within the field	(Khan, Haleem & Khan, 2020); (Spinler, & Werning, 2020); (Bressanelli, Perona & Saccani, 2019); (Moktadir et al., 2020); (Bressanelli et al., 2021)
Lack of knowledge about the potential of circularity	(Khan, Haleem & Khan, 2020); (Moktadir et al., 2020); (Govindan & Hasanagic, 2018); (Werning & Spinler, 2020)
Cultural issues due to linear mindset	(Bressanelli, Perona & Saccani, 2019); (Govindan & Hasanagic, 2018)
Fear of hurting the brand due to quality	(Bressanelli, Perona & Saccani, 2019)
Potential cannibalization when selling reused products	(Werning & Spinler, 2020); (Bressanelli, Perona & Saccani, 2019)
Collaboration with SC partners	(Bressanelli, Perona, & Saccani, 2019); (Julianelli et al., 2020)
Reverse logistics infrastructure	(Khan, Haleem & Khan, 2020); (Bressanelli, Perona & Saccani, 2019); (Moktadir et al., 2020); (Govindan & Hasanagic, 2018)
Customers	***Literature***
Cultural issues due to linear mindset	(Khan, Haleem & Khan, 2020); (Bressanelli et al., 2021); (Bressanelli, Perona & Saccani, 2019); (Govindan & Hasanagic, 2018)
Required customer effort	(Bressanelli et al., 2021)
Lack of knowledge about the potential of circularity	(Govindan & Hasanagic, 2018)
Lack of economic incentives	(Khan, Haleem & Khan, 2020)
Cyber security concerns	(Bressanelli, Perona & Saccani, 2019)

3.6 Stakeholder incentivization and collaboration

An incentive is defined as something that encourages someone to a certain behavior or to perform a certain activity (Nationalencyklopedin, n.d.). Incentives are often used by a stakeholder in a supply chain to motivate a certain change in behavior among the targeted group. In some cases, the incentives are centralized and provided

by the government and in some, they are implemented by companies (Flygansvaer, Dahlstrom & Nygaard, 2018; Song & Chu, 2019; Zhang, Gang & Han, 2019). In this thesis, the focus is on the latter.

The usefulness of incentives for e-waste recycling was proved in a study on recycling of mobile phones. The research shows that when the incentive utility increases, the proportion of customers who return products in relation to informed customers approaches 100%, thanks to incentive strategies. In practice, this means that a higher economic incentive leads to higher recycling rates. The current difficulty in providing incentives lies in the fact that retailers today spend more than they earn on recycling, due to substantial collecting costs. (Zhang, Gang & Han, 2019)

To achieve the desired outcome the purchaser can use different mechanisms based on authority, trust, and price (Bradach & Eccles, 1989). With respect to a take back system there are different types of relations to consider and different suitable mechanisms. One relation discussed by Flygansvaer, Dahlstrom, and Nygaard (2018) is the relation between a recycler and a collector, where the recycler can be seen as the purchaser and the collector as the vendor. If the parties collaborate and if the purchaser monitors the vendor's performance, their interfirm culture could be improved (Flygansvaer, Dahlstrom & Nygaard, 2018). Monitoring the vendor's behavior and collaborating enhance the shared vision and the companies' common ecological direction, which together improves the interfirm culture (Flygansvaer, Dahlstrom & Nygaard, 2018; Krishna, 2011). With a shared vision, the vendor will indirectly be pushed to perform activities that are advantageous for the entire supply chain (Flygansvaer, Dahlstrom & Nygaard, 2018). An improved interfirm culture will, therefore, enhance the performance of all three aspects of the triple bottom line by aligning the firms' ambitions and goals. The triple bottom line is the consideration of the aspects of people, planet, and profit (Elkington, 1997). In this context, people refer to the satisfaction of the relationship, planet refers to the level of product reclamations and energy savings, and profit refers to perceived financial return from the relationship.

Another relationship to consider is the one between a retailer and their customers. A retailer can choose between different strategies to optimize its recovery for e-waste. There are, for example, three different types of economic incentive strategies. Firstly, they can give a specific amount of money, a cash incentive, that can be used for buying a new product, which also increases the customers' eagerness to buy new products. Secondly, a retailer can offer a specific price preference to customers to encourage them to return e-waste and buy new products. Thirdly, they can provide a specific price discount, leading to customers willingly returning e-waste and as a consequence also buying new products. (Zhang, Gang & Han, 2019)

These three economic incentive strategies have different impacts and from the retailers' perspective give different net profits. This partially depends on the incentive utility, which when talking about economic incentives refers to the

financial usefulness or gain for the customer. When comparing the strategies, it was found that up until a certain level of incentive utility, the price-discount strategy generates the highest net profit. However, if the incentive utility is exceeding this point, the cash incentive strategy is preferred when looking at net profit. Ultimately, the study concluded that the price-discount incentive strategy is the retailers' best alternative, since they can receive the highest profit under this strategy. The second-best option is the price-preference incentive strategy. The third option, the cash incentive strategy, is not advisable because of the low profits and large changes in net profits. (Zhang, Gang & Han, 2019)

A third relationship is the one between the government and companies and how the state can give appropriate incentives to firms. Song and Chu (2019) suggest two different incentive models for electric vehicle battery closed loop supply chains. In these models, the government either incentivizes the manufacturer or both the manufacturer and retailer. In both models, the total profit increased with increased reward intensity, as well as with the number of recycled EV batteries. However, the recycling rate increased more when both manufacturers and retailers were rewarded. The article concludes that improving the recycling rate for both a manufacturer and a retailer is best done by higher reward intensity. (Song & Chu, 2019)

To conclude, there are three mechanisms to be used as incentives, based on either authority, trust, or price. As an economic incentive it is recommended to give a price discount and to keep the reward intensity high to maintain a greater level of motivation among the customers. Incentives are given to encourage a certain behavior, however, mutual interests, trust, and collaboration is always key to success.

4 Case study – Axis Communications

This chapter contains more detailed information on the case company, Axis Communication[3], to be able to grasp their preconditions to establish a take back system. This includes a description of their current supply chain in the US, and their ongoing work with environmental sustainability. Finally, the chapter addresses circularity initiatives within the electronics industry that can be used as a reference point and source of inspiration for Axis.

4.1 Current supply chain in the US

Today, Axis' supply chain in the US is linear with no established program for taking care of decommissioned products from end customers, as Figure 10 illustrates. The return flow for product failures is not considered, as repairable products or products within warranty do not count as decommissioned products.

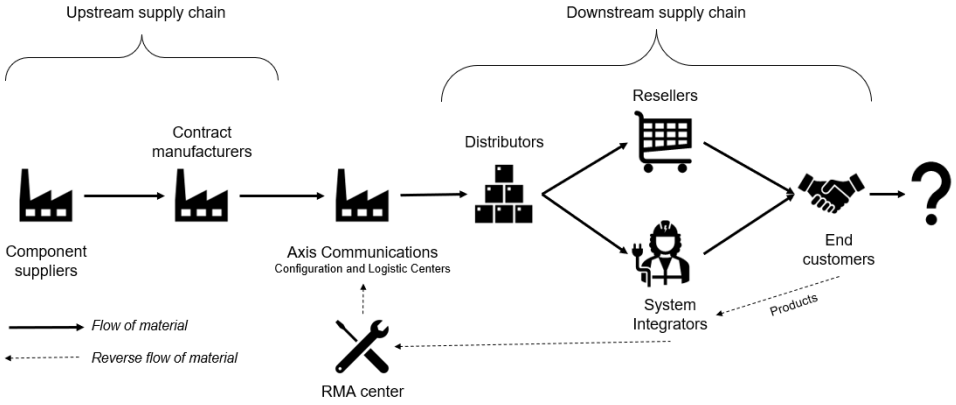

Figure 10. The current supply chain of Axis.

The supply chain starts with the component suppliers, supplying Axis' contracted manufacturers with components. The contracted manufacturers send ordered parts

[3] Information is gathered from the dialogues with P. Castensson (Reverse Supply Chain Director), G. Usenia (National Inside Sales Account Manager), and the environmental team at the headquarters.

to Axis' Configuration and Logistic Centers (CLCs). Axis has today three CLCs in the US, where products are assembled and later sent to distributors. The distributors sell products to resellers and system integrators, who ultimately sell to end customers. What happens with the products after the end customer has decommissioned them, is today unclear. When the products leave a CLC, Axis loses the ownership of the product, and thereby the control and traceability of them when they reach their end-of-life.

When selling IT equipment there is always a risk that the product breaks down for different reasons, which is handled at one of Axis' 16 Return Material Authorization (RMA) partners. There is one RMA partner in the US, near one of the CLCs. If a defect product needs RMA support, the product has to be returned through the sales channel, from which it was purchased (Axis Communications, 2021d). The turnaround time as a critical KPI within the RMA process and mentioned that by co-locating the RMA centers with the CLCs this time can be reduced. He further reminded that the current reverse flow at Axis handles only repairs.

The difference between a system integrator and a reseller is that a system integrator designs the entire system with specifications on the exact products needed for each end customer, including installation, while a reseller only provides the product the end customer has asked for. The run rate of products is typically sold through resellers, while bigger projects are usually sold via system integrators.

To encourage loyalty and partnership, and to support distribution channel partners, a partnership program is in place for partners selling Axis' products. The Channel Partner Program (CPP) offers three different levels of partnership for system integrators, value-added resellers, and installers (Axis Communications, 2021e). The three levels are authorized, solution silver, and solution gold, for which requirements and benefits are increasing when moving upwards. The requirements can be to buy products from Axis authorized distributors, reaching a certain level of installation service, committing to a Non-Disclosure Agreement as well as sharing sales and marketing plans. The benefits stretch from enhanced profit margin opportunities, Axis technology support, and listings on Axis website, to networking possibilities with other partners (Axis Communications, 2021e).

Another partnership program connected to take back in some ways is the Technology Upgrade Program. The program was developed to encourage end customers to move from analog cameras to digital cameras. For each analog camera one replaces, and shows this by destroying it, one gets a discount on a new one. Old cameras should be ethically destroyed and recycled, however there are no follow-ups on the recycling part. The end customers are allowed to send back the decommissioned products to Axis to take care of it, yet this rarely happens. There are two main challenges with the Technology Upgrade Program explaining why the program only is used to a limited extent. Firstly, to get the discount there is a lot of administrative work required because there is neither a financial relationship between Axis and their system integrators nor Axis and their end customers.

Secondly, the workload is quite high compared to the discount offered, making it hard to motivate.

In conclusion, Axis has a complex supply chain with many intermediaries before reaching the end customer. Axis has established different programs to ensure loyalty, but also to incentivize choosing an Axis product when upgrading surveillance equipment.

4.2 Environmental sustainability work at Axis

Similarly to other global companies, Axis has also set up goals to reduce their environmental impact (Axis Communications, 2021b). In the Section 1.2.2, Axis' three focus areas are mentioned; Protect Natural resources, Protect Ecosystems, and Beat Climate Change. Protect Natural resources is connected to SDG 12, responsible consumption and production, which is closely connected to circularity.

For Axis, protecting natural resources means introducing more recycled materials in their products and mapping their water consumption. The progress of their work towards greater use of recycled materials can, for example, be seen in the six new camera models, containing over 50% recycled plastic, that were launched in 2020. Furthermore, mapping the water consumption makes it possible to allocate resources where they have the greatest impact to minimize the water footprint. (Axis Communications, 2021b)

These two subgoals focus on reducing the virgin material used. However, today Axis has no statement on how to deal with their products after they are decommissioned at the end customer. To start the journey towards circularity, Axis has conducted a research project in collaboration with Vinnova, a government funded innovation agency. The aim of the project was to identify challenges and opportunities for both Axis and the industry in general to move towards a more circular economy. The report resulted in an overview of where Axis is performing well and areas where there is room for improvements. (Axis Communications, 2021b)

The Vinnova collaboration sparked the idea of taking responsibility for end customers' decommissioned products through a take back system. According to Ausra Reinap (personal communication, 7 September 2021), Axis is currently working on setting up long term goals pushing towards a take back system for Axis products. However, there are challenges with how the target should be formulated and how the goal could be reached.

To enhance the possibility of recovering materials from old products, it is important to eliminate hazardous substances in the production phase. For this to happen, Axis has stated a catchall goal, Protect Ecosystems, for avoiding and eliminating hazardous substances in Axis products, which will facilitate recycling of their

products. A certain substance might be forbidden in the future, rewarding the proactive in this area since they can reuse their recycled materials. Additionally, recyclers do not have to handle hazardous substances. The EU Waste Framework Directive has also pushed Axis to review the material and substances in their products, since the directive requires companies to submit information about products containing hazardous substances. These substances are specified in the Candidate List and must be reported to the SCIP database. (Axis Communications, 2021b)

A take back system will help Axis to make use of the resources already in the system. Recycling is a first step for Axis, later striving towards reuse of products. Reusing the products by remanufacturing and refurbishment is further a prerequisite to reduce Axis climate footprint, and thereby to Beat Climate Change.

4.3 Benchmark against the industry

Axis made a benchmark, to understand the sustainability and circular economy initiatives among competitors. The comparison was done to understand what competitors in the same field are doing. Later the scope was broadened to the electronics industry, where more inspiration could be drawn from pioneers when it comes to circularity. The reason for this broader scope, was the fact that there are fewer examples of dedicated circularity initiatives within the surveillance industry. The study looked at circular economy broadly, however, only the parts relating to take back systems and recycling are included in Table 3 below.

Important to reflect over and understand is that the main sources of information below is from the company's respective websites, where they control the wording and are trying to promote themselves. It is hard to hold companies accountable for their promises, to control the development and to know exactly what, for example, the companies' take back systems mean in practice.

The WEEE directive in the EU makes it mandatory for manufacturers to provide recycling opportunities for products that the customer no longer wants without extra fees. Thus, it is possible that some companies are providing take back in the EU, to comply with the law, but not when they are doing business outside the EU. This would of course water down their statements on their websites. Consequently, critical thinking is of essence when interpreting the companies' claims.

Table 3. Benchmark on circular economy initiatives in the electronics industry, made by Axis.

Company	*Formal goal*	*Take back initiatives*
Bosch	Bosch aims to maximize the usage and lifetime of products, and thereby resources, as well as to enhance resource and energy efficiency thanks to circular	Bosch offers a repair and spare parts service and promises that end-of-life

	economy and through Life Cycle Costing and Assessment. (Bosch, 2021)	products and scrap tools are taken back and recycled. (Bosch, 2020)
Canon	For Canon, sustainability principles are deeply rooted with over 20 years of remanufacturing and continuous technical innovation and improvements in their field. As the only Original Equipment Manufacturer (OEM) offering remanufacturing of devices, Canon remains ahead within the industry. (Canon, 2021)	Canon provides take back and remanufacturing. (Canon, 2021)
Cisco	Cisco has declared that they will move from a linear economy to a circular one to better optimize the use of finite natural resources. (Cisco, 2021)	The Cisco take back and reuse program is free of cost for the user and reuses 99.6% of materials from returned products. (Cisco, 2021)
Dell	Dell has committed to reusing or recycling an equivalent product for every product a customer purchase. Moreover, recycled materials should be used in all packaging and in over half of their product content. (Dell, 2021a)	Dell has implemented a program for resale and recycling of assets in 64 countries both for homes, home offices and businesses. (Dell, 2021b)
Electrolux	Electrolux is using recycled materials in their products and promoting packaging to be recycled by more sustainable packaging solutions. Additionally, they contribute by making spare parts accessible to be able to repair products and by looking into new circular business possibilities. (Electrolux, 2021)	Electrolux has committed to finding better recycling possibilities, especially targeting areas lacking legal obligations when it comes to product take back (Electrolux, 2021). They also established the European Recycling Platform together with Braun, HP, and Sony (Electrolux, n.d.).
Ericsson	Considering environmental factors in the product design is the first step in Ericsson's life cycle approach. This involves for example picking materials carefully, using it efficiently as well as proper reuse and recycling. During the usage of products, different services are offered to increase energy efficiency and to lengthen the lifespan of the products. A take back and data destruction service is provided at the products' end of life. (Ericsson, 2021)	Ericsson established an international take back system in 2005 and provided services in 180 countries. (Ericsson, 2021)
HP	HP aims at “keeping products and materials in use” and “designing out waste”. This is done by addressing environmental aspects in the design phase and at the end of life by being able to repair, reuse, and recycle. In the design phase also efficient use of material and	HP Planet Partners Return and Recycling Program provides services in over 45 countries (HP, 2007). HP was also a part of initiating the European Recycling Platform (Electrolux, n.d.).

	using more recycled materials are considered. (HP, 2021)	
Motorola	Motorola is an advocate for take back programs for e.g., mobile phones and batteries, including the necessary education on the subject for customers, also information online. They accept 3rd party recyclers if they satisfy the local laws on e-waste recycling. They aim to expand the usage of recycled plastics in the phone housing. Motorola promises that even global sales comply with EU Restrictions of Hazardous Substances Directive to 95%. (Motorola, 2021)	Motorola offers mobile phone and accessory take back in around 60 countries. In some cases, the phones are refurbished and resold for a low price in developing countries. (Motorola, 2021)
Schneider Electric	Schneider Electric integrates circular economy in the products and services they provide, as well as across their whole value chain. Some actions are green sourcing, green design, sustainable packaging and offering Energy Management-as-a-Service, as well as focusing on retrofitting, repairing, refurbishing, and recycling. (Schneider Electric, 2021a)	Schneider Electric provides a take back program for medium voltage end-of-life products. (Schneider Electric, 2021b)

Despite the lack of circularity initiatives among Axis' competitors, there is more inspiration to be taken from the broader electronics industry. Thanks to the fact that these companies are not direct competitors, there are also possibilities to partner up and to learn through their experiences, to find synergies, and to reach economies of scale. Further, exploring the electronics manufacturer's supply chain and environmental sustainability work is a part of the groundwork for interviews with stakeholders in the downstream supply chain as well as with the case company itself. These results are presented below.

5 Results

In this chapter, the findings from interviews with stakeholders in Axis Communications' downstream supply chain as well as with internal employees and external experts are summarized. Barriers to introduce a take back system for Axis and barriers to partake in the system for each stakeholder group are mapped. In addition to the barriers, the solutions and ideas mentioned in interviews have been summarized in this section.

5.1 Identifying barriers and solutions

To implement appropriate solutions, one needs to understand what drives people, in this case the stakeholders in Axis' downstream supply chain (shown in Figure 10), as well as Axis themselves, to make certain decisions. A number of interviews have been conducted to evaluate the potential barriers for Axis to implement a take back system, and how to overcome these. Additionally, barriers for Axis' downstream supply chain stakeholders to take part in the take back system have been investigated. The goal was to map not only challenges but also solutions from all stakeholders' point of view, with input from interviews and inspiration from theory. The full list of interviewees can be found in Appendix A.1.

5.1.1 **Axis Communications**

To implement a take back system in the supply chain, the company, initiating the initiative, needs to address barriers to overcome. Some challenges were identified during several interactive workshops with the environment team at Axis' headquarter in Lund. These challenges were complemented with barriers from theory and verified by the environmental team. In addition, other internal experts added valuable insights.

First, the deeply rooted *organizational linear mindset* was discussed. The linear mindset is one consequence of the industrial revolution and has shaped organizational cultures ever since. This overarching global challenge of moving from a linear to a circular economy runs through the veins of our society and all organizations, making it particularly tough to overcome.

Axis is no exception, and the linear mindset is mirrored in Axis' *current linear sales model*, which impedes the move towards circularity within the organization. There are several barriers for implementing a take back system due to the current sales model. Firstly, Axis has *no ownership of the products* after they have left the CLCs, which means Axis loses control of the products. Secondly, there are *many intermediaries in the downstream supply chain*, which restricts the possibilities to influence the stakeholders further down the line. Thirdly, this long downstream supply chain, and the fact that Axis does not have ownership of their products, implies *limited traceability of the products*. This makes it challenging to control and forecast the collection rates, however, a possible solution could be a database tracking each product by using their serial numbers.

Further, the current linear sales model leaves no room for selling refurbished or remanufactured products. Selling reused products makes it challenging to guarantee the same quality of those products as the new ones. The alternative is to accept a lower quality for reused products, however, whether this is desirable is another question. As a result, Axis has a *fear of brand damages, due to liability and quality concerns*. These concerns are related to both their responsibility to guarantee proper handling of returned products, as well as the actual quality and the perceived quality of the products among end customers. The end customers might change their view on Axis' product quality, even if the quality would be the same.

The linear sales model encourages the concept of producing and selling volumes, which is shown in Axis' profitability requirements as a company. The *short-term profitability requirements* are discussed to be a barrier for implementing the take back system. Recycling initiatives are still more expensive compared to disposal into landfills (Andeobu, Wibowo & Grandhi, 2021), which does not give companies clear economic incentives for implementation. This, in combination with the required *big initial investment costs*, and the *operational costs* when establishing a take back system, raises the question "who owns the cost?". The lack of economic incentives implies an *uncertain return on investment (ROI)*, and this might lead to *weak top management support* due to the shareholders' profitability requirements.

To decide whether a project is successful or not, one needs to have different measures. Together with the environmental team, it was discussed that the traditional key performance indicators (KPIs), evaluating the performance of the supply chain, might discourage a take back setup due to *misaligned KPIs neglecting the environmental aspects.* An example is that current KPIs measure sales volume of new products, which potentially could decrease if Axis were to sell refurbished and remanufactured products, and the end customers would choose these instead of buying new products. This *risk of cannibalization if selling reused products* might impede the implementation of a take back system.

Viewing the implementation of a take back system from a more practical perspective, it is noted that Axis has a reverse logistics organization for handling repairs, as mentioned in Section 4.1. However, it can be questioned if it can be scaled

up and how synergies from the current setup can be benefitted from. Due to the *limited reverse logistics organization*, Axis has *no experience within the field* of establishing a greater take back organization, and therefore this implementation will probably require more resources compared to if they already had this experience. Furthermore, with a limited reverse logistics organization and no experience, and the volatility of take back of decommissioned products, it will be difficult to predict the amounts of collected products and their quality. The *uncertain collection demand* complicates the capacity planning, and it might, therefore, be difficult to find an appropriate contract with partners.

Considering the collection demand, Axis must get their downstream supply chain stakeholders onboard to establish a take back initiative. To do so, it is important to understand their pains and gains for such an initiative. During the workshops, the stakeholders' level of risk aversion was discussed. This risk aversion is probably colored by the global linear mindset. *Stakeholders' risk aversion* is discussed to create *fear of increased workload* and *fear of increased costs.* To overcome these fears, the environmental team emphasizes the importance of a seamless procedure for the involved stakeholders, and justifiable cost management. To achieve this, Axis must be working closely with current and new partners. Furthermore, the question of *cyber security concerns* for end customers is highly relevant. It is argued that the cyber security must be guaranteed to persuade the end customers to partake.

Furthermore, the Reverse Supply Chain Director and the Global Service Manager at Axis brought up that the current RMA process is scalable. However, they highlighted some challenges when merging the existing process with a take back system for reuse and recycling. This would only be beneficial if the decommissioned parts can be reused to some extent. The Reverse Supply Chain Director underscored that if the system only is for recycling, then it is probably more efficient and better for the environment to recycle them locally, if possible, rather than to bring them into Axis to then recycle them. If the current RMA process were to be expanded, there is a risk that products needing recycling will be transported a long way to Axis instead of being recycled locally. This could be solved if troubleshooting on site is possible to determine the quality of the product and to quickly determine whether a product should be recycled locally or brought back for potential reuse.

To be able to use the current RMA process, it is important to have support from the channel partners. The Channel Partner Program strives to reward partners putting in valuable efforts for supporting Axis' sales. The Program Manager for Inside Sales and Channel Programs and the National Inside Sales Account Manager emphasized the importance of integrity, to separate the more valuable partners from the rest so that they feel rewarded for their efforts. They argue that it should not be too easy to become a gold solution partner, since that could reduce the integrity of the program.

However, the Axis experts suggest a separate incentive program for recycling within the CPP. The partners, regardless of level, could report their recycling rate of Axis products on a quarterly basis and be rewarded if they reach a certain threshold value,

set by Axis. It was argued that the reward could be both economic and non-economic incentives. Further, it was recommended to avoid incentivizing end customers to avoid risking the relationship with system integrators, as this could be perceived as Axis going behind their backs.

Worth mentioning is that there are several more challenges connected to a take back system if the ambition was to remanufacture and refurbish. However, since this thesis focuses on a take back system with the ambition to recycle decommissioned products, those additional challenges are left out. The identified challenges, and the potential solutions that came up during the discussions, are summarized in Table 4.

Table 4. Axis' challenges and solutions when introducing a take back system.

Barriers	***Solutions***
Organizational linear mindset	
Current linear sales model	
No ownership of products	
Many intermediaries in downstream SC	
Limited traceability of products	Database tracking products
Fear of brand damages due to liability and quality concerns	Accept lower quality for reused products
Short-term profitability requirements	
Big initial investment costs	
Operational costs	
Uncertain ROI	
Weak top management support	
Misaligned KPIs neglecting environmental aspects	
Risk of cannibalization if selling reused products	
Limited reverse logistics organization	Troubleshooting on site
No experience within the field	
Uncertain collection demand	
Stakeholders’ risk aversion towards new initiatives	Incentivizing through quarterly reports
Fear of increased workload for stakeholders	Seamless procedure for stakeholders
Fear of increased costs for stakeholders	
Cyber security concerns for end customers	

5.1.2 **Distributors**

Distributors have a close relationship and collaboration with Axis and is something they value. However, distributors do not have any particular impression, neither positive nor negative, when it comes to Axis' sustainability work. Regardless of the lack of knowledge on Axis' sustainability work, the distributors are positive to collaborate with Axis when it comes to recycling initiatives.

Currently, the recycling procedure is not a clearly outlined process. Distributors usually recycle internal equipment, but they do not provide any recycling services for the end customers or the system integrators. For their internal appliances, they use different recycling partners. The only end customer products that are taken back are the ones within the warranty period. Similarly to Axis, they also have little to no insight into what happens with the products after they are sold to system integrators or resellers.

Some identified barriers to taking part in a take back system were the required cost and workload, the traceability of products, and the liability. *Cost* was spoken of in general terms, and whether something feels expensive or not is subjective, however there was a general reluctance to paying for a recycling service. Further, it was discussed that the operations departments are quite busy and will not appreciate if a take back program involves more work for them. Consequently, the *required workload*, meaning time and effort, to manage the take back system was considered a barrier for distributors. For the distributors to partake, any complicated protocols to follow should be avoided to make joining effortless and time efficient.

As mentioned previously, distributors do not have great insight when the products reach their end of life and where they are when they do so. As a result, it was concluded that the *traceability* o*f the products is limited*. Additionally, due to product handling related *liability* concerns, distributors emphasize the importance of selecting a reliable recycling partner. It is essential to provide certified and trustworthy recyclers and partners to get end customers engaged.

The distributors claimed that if they were to actively partake, they would rather *provide recycling as s service themselves*, than take part in Axis' system. The distributors do not want to be or see themselves as a middleman in a take back system. If the distributors offered recycling as a service, they could charge customers for it, which would incentivize the distributors to engage in this topic. Even so, the general attitude was positive towards a partnership and toward making a take back system into a value-added service. However, they still pointed out that they need some sort of economic incentive to set up a system for taking back Axis products specifically.

Furthermore, ideas and solutions were discussed during the interviews. An idea that came up was that, when customers have products to recycle, they would receive a label with the return address. This would make the process easy and smooth for the customer and there would be multiple options of how the customers could receive

the shipping bill. For example, when buying new products, they could be anticipated to send back their old products.

One distributor uncovered that it was much cheaper for them to unpack, organize and repack the materials that they recycle internally. This served as an incentive to do some more work internally for a much cheaper service. This could be an indication that perhaps also end customers could be willing to e.g., take out SD cards from cameras in exchange for something else.

In conclusion, the overall opinions were positive towards being a part of a take back system. The barriers and solutions from interviews with distributors are summarized in Table 5. Key takeaways suggest that the easier, the better, but also that costs, traceability, and liability need to be considered.

Table 5. Distributors' barriers and solutions for taking part in Axis' take back system.

Barriers	***Solutions***
Costs	Economic incentive
Required workload	Smooth process, return labels to print
Limited traceability	
Liability concerns	Hire trustworthy recycling partners
Provide recycling themselves	

5.1.3 System integrators

One common denominator for interviewed system integrators is their relationship with Axis. They see Axis as a strategic partner and highly value their quality and technology competences. However, none of the system integrators have any thoughts of sustainability work at Axis. On one hand, this is because they choose Axis for their technical skills and not for their sustainability work, and on the other hand, because they have not been educated in this area. Furthermore, the system integrators have not noticed any particular requests from their customers regarding sustainability. This further affects the system integrators' willingness to look for sustainable solutions. It is pointed out that the lack of sustainability pressure from end customers can be a consequence of their location in the US, since different regions in the US have different sustainability requests.

The current procedure for decommissioning products varies from system integrator to system integrator. One of the system integrators always takes care of the decommissioned products, one takes care of the products half of the time, depending on the request from the end customer, and the last one leaves everything but recommends different recyclers that the end customers could use. Nevertheless, none of them have any insight into how the e-waste is handled.

The willingness to participate in a take back program in collaboration with Axis differs between system integrators. One is reluctant to partake at all, while the other two are positive to the idea of participating in a standardized take back system to simplify their processes. Some barriers brought up are *cyber security concerns*, for the users of the products, *the costs*, and the fact that the *products have a value*, making them assets. Because of the cyber security concerns, there might be a reluctance towards Axis refurbishing old products. Because the products are assets to the end customers, even if they would be old, this could imply that money needs to be transferred when giving up assets. Additionally, there are some *concerns about the secondary market size* as well as the amount of required *administrative work*.

Furthermore, interviewees discussed what enables a take back system. The system integrators agree that the cost should be kept low, and that the cost should be built-in into the front-end not to intimidate the end customers. It is further emphasized that the administrative process should require minimum effort. To overcome cyber security concerns, a certified automated process for resetting the products to factory default is suggested. It is underscored that it needs to be automated to avoid human errors. Additionally, different incentives to engage the end customers are mentioned. All sorts of tangible benefits are argued to be beneficial, such as discounts, “first in line” prioritization e.g., during product launch, and gathered data on recycling rates. It is pointed out that if an end customer is wealthy, non-economic incentives could be more beneficial than economic ones, such as discounts.

To sum up, the readiness to be a part of a take back system varies between Axis' system integrators. However, there is a consensus among the system integrators regarding the barriers to consider and potential solutions. The identified challenges and solutions are summarized in Table 6 below.

Table 6. System integrators' barriers and solutions for taking part in Axis' take back system.

Barriers	***Solutions***
Cyber security concerns	Certified, automated process for resetting to factory default
Costs	“Built-in” costs
Workload	Easiness in the procedure
Value in assets	Tangible benefits
Uncertainty about the secondary market size	

5.1.4 **End customers**

Axis has not made any impression on the end customers when it comes to progressive sustainability work. Additionally, end customers feel like system integrators do not care about sustainability and what happens to the products after

they are sold. They felt like it was their responsibility as the end customer to make decisions on how to handle the products.

Interviews confirmed what system integrators said about sometimes leaving the products with the end customer, after uninstalling them, and sometimes bringing the products back with them. It was also mentioned that one end customer takes down their products themselves, and in this case, they are also responsible for decommissioning and disposal.

One interviewed end customer emphasizes their responsibility towards taxpayers due to their position as a public company. Therefore, they want to efficiently use the taxpayers' money, but also to face the liability involved with handling the decommissioned products. This end customer already has a recycling procedure in place involving auctioning products for reuse and recycling, but also focus on prolonging the lifetime of products and keeping products in use in their own facilities if possible. From a manufacturer perspective, selling a new product generates more revenue than selling a used product, however the end customer has not heard about fear of cannibalization among manufacturers and see no problem with their current way of auctioning products.

In general, end customers were positive towards a recycling take back system. This would of course be seen as even more attractive if it would include discounts or other types of incentives, which, for example, could involve talking to engineers about end customer specific needs and solutions. Internal Axis experts even advised against economic incentives for the end customer with the argument that it would be an *administrative process for the end customer* as Axis has no monetary relationship with end customers. Instead, they suggested that the incentive should be provided to the system integrator, who in its turn could decide how to incentivize the end customers. It was acknowledged that there are companies buying back their old products, making this an economic incentive for end customers to send decommissioned products back. This was presented as an idea for Axis.

It was also mentioned that end customers could pay for a recycling service, if this guaranteed that the products are taken care of properly. Nevertheless, one substantial barrier brought up was the *cost* of the take back program for the end customers sending their decommissioned products to be recycled. A built-in cost was proposed where the cost for the program specifically would not be displayed but rather as a part of the other services such as free repairs within the warranty period. It was speculated that it is unlikely that end customers would pay for a recycling service separately.

In addition to addressing the price, end customers also expect a seamless and easy process to partake in a recycling program. They want to avoid *administrative processes* at all costs. The reason for this is that *recycling has a low priority* in companies. If the process is not simple and standardized, it will get chaotic as many big end customers use many system integrators when installing or uninstalling products. An idea that was brought up to address this was to have a QR-code on a

box that would only need to be scanned and then sent off to the recycling center. If end customers were to join a take back system, since the process is effortless, another *concern is cyber security*. End customers need guarantees that the products are handled properly at the end of life.

Further, it was suggested that this take back system should be included in the current RMA process as the end customers are familiar with the current repair process, where they send their broken products to the system integrator. It was said that even if this would be a paid service, it would be a good option in the long run. However, even with a functioning take back system, Axis would face the problem of technicians at the end customer *not seeing any difference between Axis' and competitors' products*. This discourages the setup where end customers themselves send back products, as they might not have the skills to separate the products.

In conclusion, end customers are positive towards partaking in a take back system for decommissioned products. However, there are some challenges related to implementing such a system. The challenges identified together with suggested solutions are summarized below in Table 7.

Table 7. End customers' barriers and solutions for taking part in Axis' take back system.

Barriers	Solutions
Cyber security concerns	Guaranteeing proper handling
Costs	Build-in cost
Low priority to recycle	Ease of using the service
Difficult to distinguish between Axis' products and competitors'	Included in current RMA process
Administrative process	QR code on a box

5.1.5 External experts: Recycling service provider

Other stakeholders within the industry, such as potential partners and experts, were interviewed for two main reasons. Firstly, to validate results and secondly, to evaluate possible partnerships for Axis. In a take back setup for recycling, mainly partners for transportation and recycling would be needed. The initial consideration within this thesis was determined to be the latter, which was why interviews were conducted with recycling service providers (RSPs). This decision was made because RSPs typically provide the transportation in their service.

The take back procedure for recycling was described by an RSP. The solutions they provide are tailored according to each customer's specific needs, and here the customer is the company in need of recycling services. In the first step, the company picks up the customer's products and drives them to their site, where all the data is

wiped. In the second step, the RSP tries to resell the products that are possible so resell and in the last step the rest is recycled.

The RSP highlighted the *logistics costs* and the *difficulty to predict costs* as barriers for customers to participate in recycling initiatives. The difficulty to predict costs is due to the uncertainty of quantity and type of products that the customers want to recycle. Additionally, the *fear of cannibalization*, *regional differences in attitudes towards sustainability*, and *lack of incentives* in place might discourage customers' circularity initiative. The RSP brought up that in some cases the environmental factor is enough, but usually some kind of economic incentive is needed.

There are also challenges for the RSPs to take into account. When offering a customer an opportunity to recycle electronics, there is an imminent risk that the *customer wants to recycle all electronics* at the company, which might include lights, batteries, and even fridges. This makes it difficult to plan and to optimize the processes. Another challenge is how to handle the smaller customers. *Many small customers will increase the workload* substantially, due to coordination and administration, leading to large costs for a small revenue. Further, if the aim is to resell, the RSP emphasizes that *a secondary market must exist* for the product and that cannot be assumed.

For Axis to be able to establish a take back system with a recycling partner, the RSP gave some advice. First, the geographic location for the take back system must be determined to investigate the regional laws and regulations in place. The location will also affect available recycling partners with a geographical spread that suits the purpose. Further, Axis needs to clarify the purpose of the take back system to the recycling partner, which for Axis as a first step means destroying and recycling products, and no reselling of them. The RSP recommends that the chosen recycling partner should have some certification, they suggest either e-Stewards or R2. Regarding the logistics partner, the number of pickup points should be defined, and for Axis it should be as many as possible in the chosen geographical area, the US. The RSP warns Axis about big masses of small customers and suggests that Axis should try to avoid these as they mean a lot of work for little revenue and impact.

Considering incentives for Axis the RSP underlines that there is a difference between recycling and reuse programs. Recycling means cost-only unlike reuse programs, where reusable products are resold and therefore, the economic challenges are bigger for recycling programs. Axis is advised to start with a pilot program through a couple of channel partners before scaling up. The RSP also stresses the fact that Axis is neither a logistics company nor a recycling company, hence they should outsource the activities connected to the take back system.

5.1.6 External experts: Technology and electronics manufacturer

Additionally, a technology and electronics manufacturer, providing recycling services, was interviewed. The company is a market leader with a global standardized procedure for taking back assets from customers and takes care of it. They provide a comprehensive take back system for not only their own IT products, but also for other companies who want to be a part of the system.

Today they offer packing, picking up, wiping the data, sorting, and reselling, or recycling IT products. The products are either reused as a whole or only some components, and third parties are used to ensure proper recycling and efficient transportation. The company has different setups for B2B and B2C but covers both sides. In this thesis, the focus is on the B2B side to evaluate Axis possibilities to partner up with the company.

The company has a long experience, over 20 years, within the recycling and reuse of electronics and has provided Axis with some hands-on tips on establishing a take back setup. The first step is to set up a standardized procedure to take back products for recovery. A standardized procedure is a critical success factor for global companies. Except from taking a holistic approach, some higher-level elements need to be considered and will be presented below.

It is important to erase all data from products if they are resold, but also consider how to properly report back to the customer, as this will give them more reason to trust the provided service. Additionally, companies wanting to provide a reuse and recycle service should look into whether the assets are processed correctly, whether the lifetime of products is prolonged when it can be, and whether any recovery value comes back to the customer. A final consideration is how easy the service is to use, as this will be one of the main pain points for the customer, which could be managed by leveraging today's technology and digitalization. Further, it was mentioned that it is important to understand how technology and digitalization can be used in the processes to improve the management of waste and how to provide the requested real-time information to customers. However, it all ultimately boils down to the project being economically viable, as we live in a capitalistic world.

In addition to the setup considerations, some barriers for their customers to join their take back program were discussed. First and foremost, this company provides a paid service and typically the *costs* are the most substantial barrier. They explained that this could be overcome by explaining the security and simplicity by choosing their service.

How concerned customers are about *data security* depends on the customer and industry. Nevertheless, documentation and certification are important to guarantee that the data is correctly handled. This increases the transparency, and thereby builds trust between customers and the company. Customers are more and more sensitive to data breaches, and therefore they want to standardize the procedure for handling e-waste. For this, they typically want to use a professional service provider with a

strong and reliable brand. This might be an enabler to choose the interviewed company's service.

Three other important enablers are that customers want to receive a recovery value from their assets, they want to specify whether their products can be resold or not, and that it is easy to join the tack back system.

In conclusion, industry experts have great insight into take back systems and recycling and can consequently validate results from interviews. The observations on barriers and potential solutions, from both the RSP and the technology and electronics manufacturer, are concluded in Table 8 below.

Table 8. Industry experts' views on barriers and solutions for Axis' take back system.

Barriers	Solutions
Logistics costs	Getting recovery value from assets
Uncertainty of quantity and type makes costs unpredictable	Utilize technology and digitalization
Fear of cannibalization	
Geographical differences in recycling behavior	Start piloting in progressive areas
Lack of incentives	
Getting all the customers' electronics	Clarify the purpose of the take back system
Small customers increase the workload	
Uncertainty about the secondary market size	
Data security	Documentation and certification

5.1.7 Summary of barriers and solutions

During the data collection phase many barriers were identified from different perspectives. These barriers are compiled in Table 9 below, where barriers mentioned by each stakeholder are pointed out specifically.

Table 9. Barriers for all stakeholders compiled.

Barriers	*Axis communications*	*Distributors*	*System integrators*	*End customers*	*External experts*
Organizational linear mindset	Organizational linear mindset				
Corporate strategy					
Current linear sales model	Current linear sales model				
No ownership of products	No ownership of products				
Many intermediaries in downstream SC	Many intermediaries in downstream SC				
Limited traceability of products	Limited traceability of products	Limited traceability			
Fear of brand damages due to quality concerns	Fear of brand damages due to quality concerns				
Finance					
Short-term profitability requirements	Short-term profitability requirements				
Weak top management support	Weak top management support				
Misaligned KPIs neglecting environmental aspects	Misaligned KPIs neglecting environmental aspects				
Uncertain ROI	Uncertain ROI				
Operational & investment costs	Big initial investment costs				Logistics costs & Small customers increases workload
Risk of cannibalization if selling reused products	Risk of cannibalization if selling reused products				Fear of cannibalization

Uncertainty about the secondary market size			Uncertainty about the secondary market size		Uncertainty about the secondary market
The electronics manufacturer & upstream supply chain					
Limited Reverse Logistic Organization	Limited Reverse Logistic Organization				
No experience in the field	No experience in the field				Getting all the customers' electronics
Uncertain collection demand	Uncertain collection demand				Uncertainty of quantity and type
Downstream supply chain					
Stakeholders' risk aversion towards new initiatives	Stakeholders' risk aversion towards new initiatives				
Fear of increased workload	Fear of increased workload	Required time and effort	Workload	Administrative process & Difficult to distinguish between products	
Fear of increased costs	Fear of increased costs	Costs	Costs	Costs	
Cyber security concerns	Cyber security concerns	Liability concerns	Cyber security concerns	Cyber security concerns	Data security
Low priority to recycle				Low priority to recycle	Lack of incentives
Geographical differences in recycling behavior					Geographical differences in recycling behavior
Value in assets			Value in assets		

In addition to identified barriers, potential solutions to the barriers were brought up during the data collection phase. These suggested solutions were matched with appropriate barriers in correspondence with the environmental team at Axis, see Table 10 below. Worth bearing in mind is that there can exist multiple solutions for every barrier, yet only one solution per challenge is suggested below because only one solution per barrier came up during interviews.

Table 10. Possible solutions for Axis to challenges with a take back set up.

Barriers	Solutions
Organizational linear mindset	Mindset shift through education
Corporate strategy	
Current linear sales model	Innovate sales model
No ownership of products	Service agreement
Many intermediaries in downstream SC	Direct agreement between stakeholders and recycling partners
Limited traceability of products	Introduce database to track products
Fear of brand damages due to liability and quality concerns	Address future concern on brand image
Finance	
Short-term profitability requirements	Focus on long-term profitability, accept more risk
Operational and investment costs	Plan for minimized costs
Uncertain ROI	Accept lower ROI
Weak top management support	Presenting viable business case
Misaligned KPIs neglecting environmental aspects	Project team for reviewing current KPIs
Risk of cannibalization if selling reused products	Address future concern on cannibalization
Uncertainty about the secondary market size	Conduct a secondary market analysis
The electronics manufacturer & upstream supply chain	
Limited reverse logistics organization	Expand current RMA process
No experience in the field	Outsource to partners
Uncertain collection demand	Develop decommissioned forecasting tool
Downstream supply chain	

Stakeholders' risk aversion towards new initiatives	Collaboration through Partnership Program
Fear of increased workload	Seamless procedure
Fear of increased costs	Built-in costs
Cyber security concerns	Hire certified recycling partners
Low priority to recycle	Demonstrate the environmental impact
Geographical differences in recycling behavior	Allocating focus according to demand
Value in assets	Tangible benefits

5.2 Clustering of barriers

The barriers identified for the case company have given insights into what barriers electronics manufacturers face when implementing a take back system. The barriers that the case company faces are assumed to represent the barriers for electronics manufacturers in general. When compiling the barriers, the authors divided the barriers into four overarching clusters, seen in Table 9 and Figure 11. These are *Corporate strategy*, *Finance*, *The electronics manufacturer & upstream supply chain*, and *Downstream supply chain*. These clusters will be further defined below. In addition to these clusters, there is an overarching barrier, organizational linear mindset, that spans over all clusters.

The cluster, *Corporate strategy*, refers to barriers related to the business and sales model. This aspect can influence the possibilities to implement a take back system. For example, the business and sales model are long-term decisions and guidelines, making them challenging to affect.

Closely related to the corporate strategy is the *Finance* cluster, which relates to the shareholders' profitability requirements. As shareholders need to be guaranteed both the short- and the long-term profitability of the company, the management needs to balance the funds according to their best judgment. Historically, the short-term profitability has been favored over some environmental initiatives with longer payback times and less likelihood of being profitable in the short run.

The cluster, *The electronic manufacturer and its upstream supply chain,* includes all barriers related to the internal competences, capabilities, and experiences as well as everything related to the upstream supply chain such as manufacturers and suppliers. However, more barriers to tackle for the upstream supply chain will occur when continuing towards reuse. In this cluster the barriers tend to be more operational than in the two clusters previously mentioned.

The supply chain continues downstream where other challenges are identified. These challenges, associated with the *Downstream supply chain*, covers all possible stakeholders in the downstream supply chain, as well as transportation and recycling partners. Getting these parties on board can be seen as a critical success factor for implementing a take back system.

Figure 11. Clusters to categorize the barriers for an electronics manufacturer.

As stated previously, the number of barriers to overcome quickly becomes large. Therefore, it is of utmost importance to have a clear process for prioritizing them in order to overcome them. When compiling barriers from the data collection, the authors observed that some barriers were related to each other. Some barriers were identified to be a consequence of another, hence it became clear that the challenges could be classified into either causes or effects, similarly to what Khan, Haleem, and Khan (2020) propose.

The authors recommend to, as a first step, prioritize the solutions to the causes as these will naturally address and solve the underlying barriers, in line with recommendations by Khan, Haleem, and Khan (2020). However, the interconnection between the solutions should be kept in mind (Werning & Spinler, 2020), since prioritizing a solution tackling an effect can sometimes be more efficient compared to tackling the cause. This can be the case if the solution to the effect implies a smoother implementation and less resistance within the organization.

To visualize the barriers and their categorization, Table 11 was designed. The visualization consists of the four different clusters and the belonging causes and effects represent the barriers for the case company when implementing a take back system.

Table 11. Clustered barriers for electronics manufacturers implementing a take back system.

Cause	*Effect*
Organizational linear mindset	
Corporate strategy	
Current linear sales model	No ownership of products Many intermediaries in downstream SC Limited traceability of products Fear of brand damages due to liability and quality concerns
Finance	
Short-term profitability requirements	Weak top management support Misaligned KPIs neglecting environmental aspects Uncertain ROI Operational and investment costs Risk of cannibalization if selling reused products Uncertainty about the secondary market size
The electronics manufacturer and upstream supply chain	
Limited reverse logistics organization	No experience in the field Uncertain collection demand
Downstream supply chain	
Stakeholders' risk aversion towards new initiatives	Fear of increased workload Fear of increased costs Cyber security concerns Low priority to recycle Geographical differences in recycling behavior Value in assets

5.3 Solution Evaluation Matrix

As discussed above, finding solutions to overcome barriers and further how to prioritize the solutions, is essential when establishing a take back system. To be able to do this, the authors recommend starting by identifying possible solutions for each barrier in each cluster in Table 11. This was done by the authors in the data collection phase, and the solutions are presented in Table 10 above. When solutions are found, they need to be prioritized, and how to do this will be presented below.

The authors of the thesis have developed a Solution Evaluation Matrix, see Figure 12, by adjusting and applying the principle of the circular economy matrix conducted by Werning and Spinler (2020). The purpose of the developed matrix is to show the potential of a specific solution. The y-axis measures the execution

capacity, addressing both the ability and the willingness within the company to execute the solution. The x-axis assesses impact on implementation, demonstrating how much the solution will contribute to the implementation of a take back system. Thus, when solutions are found to the identified barriers, each solution should be evaluated and placed in the Solution Evaluation Matrix. The authors suggest that the solutions placed in the upper right corner of the matrix should be prioritized.

Note that the authors recommend another way of prioritizing than Werning and Spinler (2020) in their circular economy matrix, since the axes differ. The y-axis is essentially the opposite to the one proposed by Werning and Spinler (2020). The authors of the thesis argue that for the purpose of implementing a take back system for recycling, the solutions that have the greatest impact and that are easiest to implement will contribute the most to the initiative.

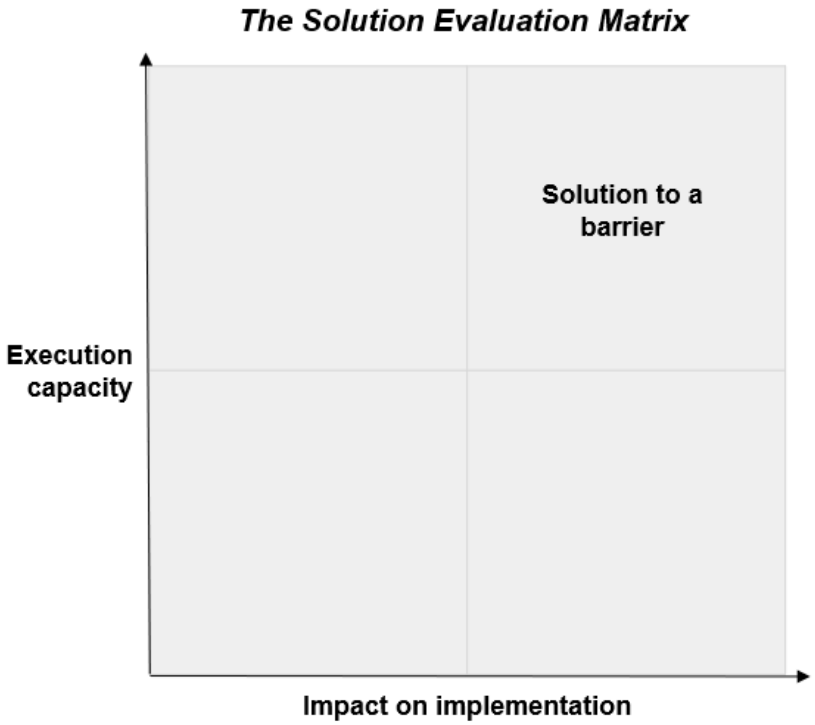

Figure 12. The Solution Evaluation Matrix.

In correspondence with the environmental team at Axis, the suggested solutions for all the barriers (Table 10) were evaluated and placed in the Solution Evaluation Matrix. To find the solutions to prioritize, every cluster was given their own matrix and the most desirable solutions, placed in the upper right corner, were picked out. This prioritization will lay the foundation for the recommendations and roadmap for an electronics manufacturer's way forward when implementing a take back system. To exemplify this, a detailed description of all solutions and justification for their

placement in the Solution Evaluation Matrix for the first cluster, Corporate strategy, is done below. The solutions for the other three clusters and their application of the Solution Evaluation Matrix can be found in Appendix B.1.

5.3.1 Solution Evaluation Matrix: Corporate strategy

Within the Corporate strategy cluster, some potential solutions handling the current linear sales model and the related effects are assessed. These are visualized in Figure 13. The solution to the cause, current linear sales model, is *innovating the sales model*, and is highlighted in black, contrary to the underlying barriers in gray. Innovating the sales model is viewed as something with a medium impact on the implementation, but a fairly low execution capacity. An assumption is that electronics manufacturers often have a linear sales model and find it well-functioning and efficient, otherwise they would innovate the sales model. The other barriers in this cluster are identified to be effects in relation to the current linear sales model. Despite this barrier being a cause, the presumed reluctance to innovate the sales model argues for focusing on the solutions to the effects instead of the cause.

If the ownership of the products were to be changed and tackled, this could be done by introducing some kind of *service agreement* to maintain ownership of the products. However, this would be a tedious process and requires time and resources to negotiate these agreements with end customers, making the execution a little harder. Also, the impact on implementation is medium level, as this alone would not support the take back system substantially.

Related to the fact that electronics manufacturers typically do not own their products, the traceability of products becomes challenging. This could be dealt with by having a *database to track the products via serial numbers or chips on the products generating real-time data*. It was brought up that having a chip could be hard to implement as the placement of surveillance equipment might be a sensitive topic to the end customers, which is why serial numbers are preferred. This would promote life cycle management and life cycle calculations, and thereby a transition to a circular economy. This suggested database is considered to both have a medium level impact on the implementation but also to have medium execution capacity.

Further, the issue with the current sales model involving many intermediaries can be undertaken by having contracts and *agreements directly between stakeholders and recycling and transportation partners.* Previously, when establishing incentives programs for end customers, Axis faced challenges, since they did not have the end customers' banking details, making the whole process very administrative and inefficient. Therefore, having an agreement with a recycling partner and recommending or requiring all end customers to hire this company, potentially for a reduced price, the challenge with many intermediaries could be sidestepped. Axis has high capacities to execute this thanks to many partners wanting to collaborate with Axis. All customers need to dispose of their decommissioned products, and if

this is possible with little effort at a fair price, they will be positive to partake. For this reason, direct agreements with recycling partners would have a fairly high impact on the implementation of a take back system.

Corporate strategy is closely tied to the brand, and damages to the brand is considered a severe threat. However, the damages on the brand as a result of reusing initiatives is considered a future barrier. The reason for this is that the damages would be a result of end customers' lower perceived quality of the electronic manufacturers' products if they were refurbished or remanufactured. *Addressing brand concerns* when establishing a take back system with the purpose to recycle, will, therefore, only have a small impact on the implementation while the execution capacity is quite high.

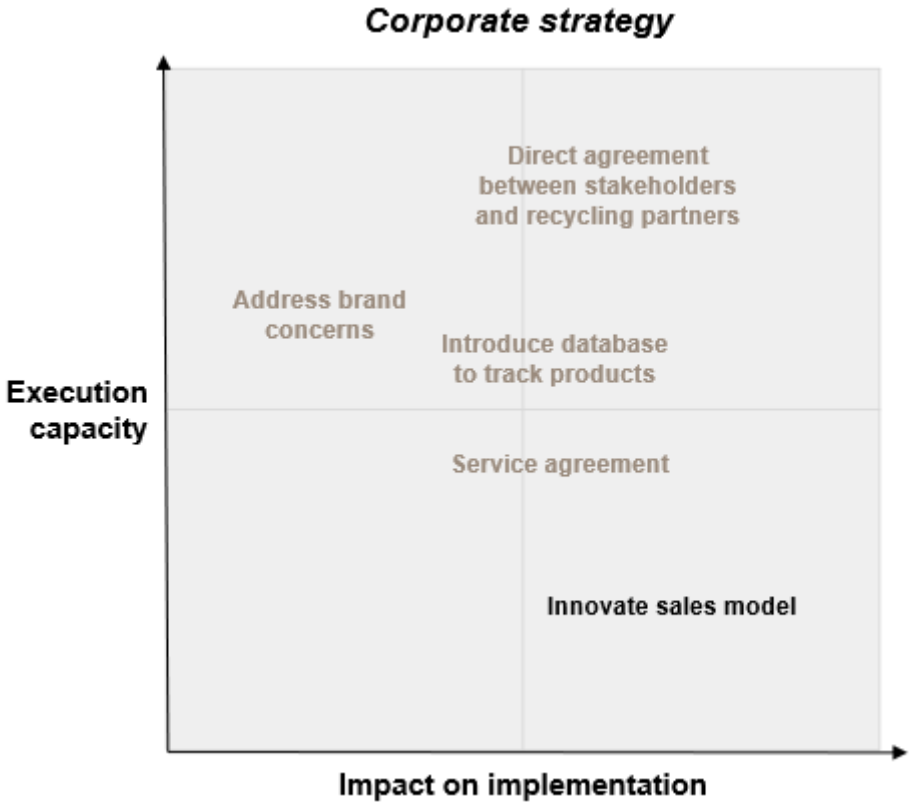

Figure 13. Potential solutions, focusing on the current linear sales model.

5.3.2 **Final prioritization in Solution Evaluation Matrix**

As mentioned above, solutions in all four clusters were placed in the Solution Evaluation Matrix. As a last step, the solutions that were placed in the upper right corner, from the four matrices, were merged into one Solution Evaluation Matrix,

see Figure 14. These challenges are recommended to be prioritized. One should notice the highlighted solution in yellow, which is not mentioned in any of the matrices above. The current linear mindset and the related cultural challenges with transitioning to a circular economy hinders the implementation of a take back system.

The current linear mindset can be addressed and *changed through education* and workshops, which in itself is possible to execute. However, having these workshops often enough, and putting enough effort into them to change the mindset of the whole organization, all partners, and all end customers will be a long and expensive process making the execution capacity medium level, but the impact on implementation quite high. This solution focuses on a mindset change within an electronics manufacturer and even if they cannot change the global mindset, they can be a part of the initial initiatives towards changing this. Currently, a slower organic mindset change is happening in society as a result of pressure from consumers and companies leading to legislation change. This organic change can benefit an electronics manufacturer introducing a take back system, however, to be a pioneer, further efforts, for example, in the form of workshops is needed.

Merging the upper right corners of the four Solution Evaluation matrices into one, reduces the solutions to prioritize from 23 to 14, which can still be seen as quite many. Notable in the upper right corner solutions to two causes, in a black font, need addressing. The rest of the solutions are solving underlying barriers and the mindset change is, as mentioned above, an overarching global challenge. However, when noticing where *outsourcing to recyclers* is placed in relation to *expanding the current RMA process*, both in the same cluster, one can see that outsourcing should be executed first according to the authors' prioritization rule. This is both easier to execute on and have a greater impact on the implementation.

As mentioned above, it is important to understand the interconnection between the barriers. This interconnection should be kept in mind when designing a roadmap to establish where to start with a step-by-step approach. For example, when looking at the interconnection of the solutions in the upper right corner, one can notice that *hiring certified recycling partners*, *outsourcing to partners*, *guaranteeing proper handling*, and assuring a *seamless procedure* will all be solved if the recycling service is outsourced to certified partners.

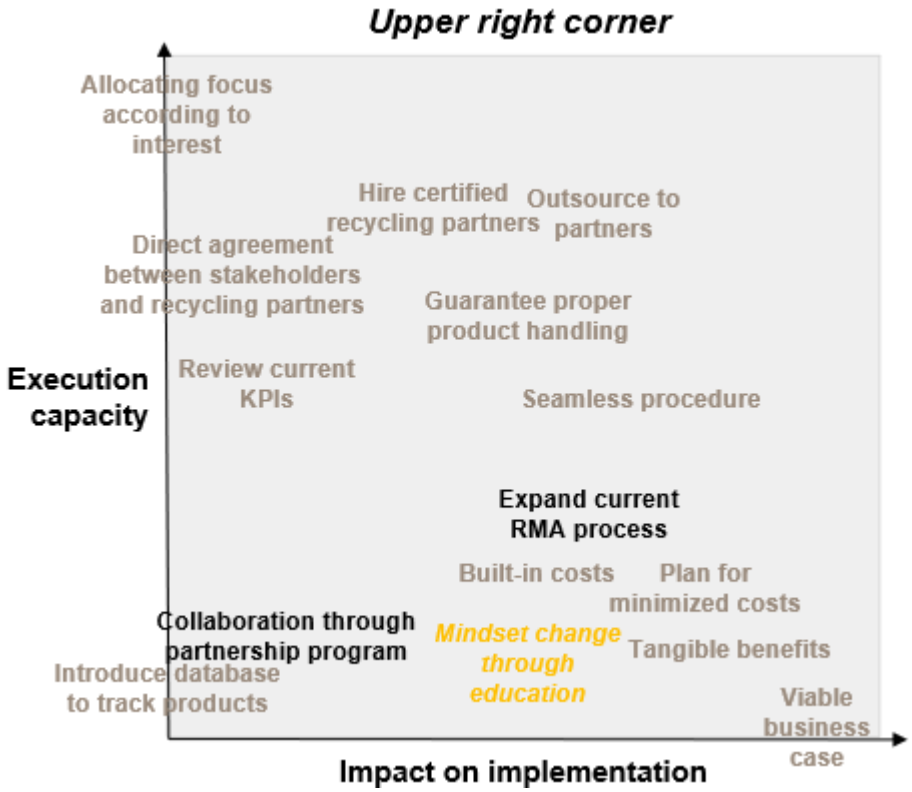

Figure 14. Potential solutions placed in the upper right corner of the Solution Evaluation Matrix.

This upper right corner has been used as a guideline for outlining a roadmap on how to establish a take back system for recycling. The roadmap for Axis, together with analysis of differences between academia and practice as well as a generalized framework, among other things, will be presented in the discussion below.

6 Discussion

The discussion consists of a gap analysis followed by a roadmap for how an electronics manufacturer, Axis, can implement a take back system. After this, a generalized framework for electronics manufacturers to overcome barriers when establishing a take back system is presented, as well as proposed future research and the limitations of this study.

6.1 Gap analysis

While conducting interviews and performing the literature review, some differences between theory and practice, when it comes to barriers, were spotted. In practice, within companies, certain barriers were given more weight and in general fewer were mentioned. Theory mentioned a whole pallet of barriers, many of which were not at all brought up in interviews. Interestingly, many aspects brought up in theory related to the reverse logistics infrastructure, for example, how to set up the system, which stakeholders' support that was needed. When comparing this to practice the worries were weak management support and risk aversion among stakeholders.

One finding, when answering research question 1 and 2, is the lack of focus on the end customers' perspective in theory. This can be noticed by reviewing the number of challenges identified for end customers in relation to the substantially higher number of challenges identified for the company, see Table 2 in Section 3.5. For a company that does not possess their own products, the authors of the thesis stress the importance of getting end customers onboard, and therefore, the high relevance of understanding the end customers' barriers to partake. Consequently, this study is highly relevant for electronics manufacturers and for academia, as there are only little practical case studies within the existing research. The lack of practical case studies might be a further explanation to the gap between theory and practice.

Interviews suggested that the most substantial barriers for the partners in the downstream supply chain would be cost and how easy the process would be for them specifically. The partners' impression was that a take back system would be something highly operational, which might be a reason for resistance to partake. This operational view can depend on the roles of the interviewed people. Many of the interviewees had mainly operational tasks and were, therefore, concerned about a potentially increased workload. An interesting observation is that the substantial

logistics costs are often commented on in literature when addressing the company's perspective. However, the company's and partners' operational efforts and requirements are not equally commented on.

Another topic that was mostly focused on in theory and only indirectly in interviews was the trust between all parties involved in a take back system, and how this can either make or break a collaboration towards a take back system. A reason for this could be that the company and their partners see collaboration and trust as a natural part of introducing a take back setup. This conclusion is strengthened by both interviewed external industry experts who discussed the importance of trust from the end customers, while the interviewed partners do not mention this.

With gained trust from partners, an electronic manufacturer can guide the partner's behavior in a certain direction. Bradach and Eccles (1989) explain that different mechanisms can lead to gained trust and can, therefore, be used to achieve these desired outcomes. For the case company, the desired outcome is to get both distribution partners and end customers to participate in the take back setup. However, a certain risk aversion among these stakeholders is identified, and an electronics manufacturer needs to find appropriate mechanisms to overcome this.

Further, some general insights were gained when answering research question 1 and 2. There are a large number of barriers and possible solutions that need to be addressed when implementing a take back system, which gives an understanding that companies have to put in a lot of effort to succeed. Even if this thesis does not address external aspects, the authors argue that the value of pressure from consumers and end customers, as well as governmental incentivization and legislation, should not be disregarded. Furthermore, to be able to prioritize solutions for creating a roadmap, answering research question 3, it is important that the company's purpose of the take bake system is defined.

In conclusion, the theory and conducted interviews align and support each other in many aspects, which strengthen the findings of this thesis. There is a clear lack of evaluation of the end customers' view in a B2B perspective and what factors or incentives that would enable or hinder a close collaboration based on trust and mutually aligned goals.

6.2 Roadmap and final recommendations

After deciding on a prioritization of solutions, the authors' have outlined a roadmap for an electronics manufacturer, displayed in Figure 15. The initial suggestion is that education and workshops, to teach about the potential of circularity, should be held continuously and regularly throughout the process, since mindset changes are difficult to achieve. Simultaneously, some larger pilot stakeholders in the downstream supply chain should be found in the same geographical area, where the

environmental sustainability interest is high, to be able to kick-start a pilot project. As interviews showed that nobody is aware of Axis sustainability work, starting the dialogue with pilot customers will also strengthen their sustainability brand. This will likely be the case for other electronics manufacturers as well. In Axis' case, the pilot stakeholders are recommended to be system integrators and end customers.

To quickly and smoothly set up possibilities for end customers' products to be recycled, the electronics manufacturer is recommended to start with outsourcing the recycling service to a certified partner. For this, the electronics manufacturer needs to evaluate recycling service providers, who take care of the recycling and transportation, to ensure that they have appropriate certification, and numerous pickup spots. The electronics manufacturer should reach an agreement with the recycling service provider where their products can be recycled at a discounted price in exchange for them recommending all their end customers and channel partners to use this company. After kick starting the process, the involved parties should, with the support from the electronics manufacturer, try to plan for minimized costs. The interviews revealed that through experience and by smaller adjustments in the process, like packing yourself, large costs could be cut.

In the next step, the electronics manufacturer should examine how the RMA process can be used. They also need to investigate how they could sidestep the problem with taking back decommissioned products that cannot be reused and only will be recycled. The expansion of the RMA process will be critical when they continue their journey towards circularity and climb the waste hierarchy. The examination of expanding the current RMA process is also favorable for Axis' initiative in providing more repair services.

When the logistics setup is arranged, the electronics manufacturer needs to get the downstream supply chain partners onboard. The authors recommend Axis to focus on system integrators and let them in turn incentivize the end customers. For this, Axis is advised to further evaluate possible tangible benefits suitable for the purpose. It is further advised that electronics manufacturers should not focus on economic incentives like discounts, but rather other types of tangible benefits such as free training or products.

To be able to take this initiative further, the electronics manufacturer is in need of a viable long-term business case for reuse. Therefore, when the key elements of the setup are in place, the electronics manufacturer should start examining and formulating such a business case. Due to the current mindset and the profitability requirements, this is argued to require support from the management team. Moreover, the electronics manufacturer is advised to put together a project group that will review the current KPIs and how they can be adjusted to encourage environmentally sustainable initiatives. Adjusting the KPIs will also boost the mindset shift towards circularity rather than linearity.

Designing the business case and reviewing the KPIs need to be done continuously and will require some time and resources. On the contrary, the introduction of

incentives for partners, is a shorter process. The idea with the incentives is that partners exceeding a certain threshold value receive some tangible benefits, to encourage their recycling behavior. To be able to track this, a process for reporting the recycling rates is needed. Therefore, the introduction of a database tracking products by using serial numbers is proposed to be executed.

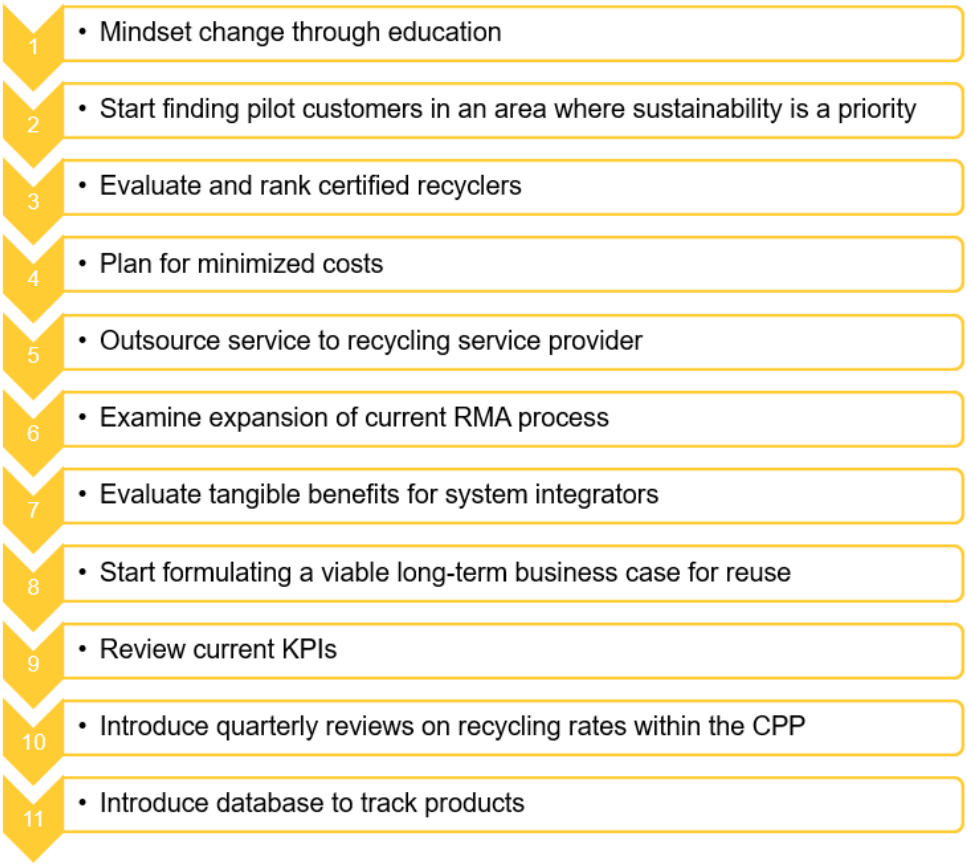

Figure 15. Axis short-term roadmap for establishing a take back system in the US.

When this initial take back system is in place, the electronics manufacturer should continue their journey towards circularity by examining the opportunities of a take back system for both reuse and recycling. This will include scaling up the current RMA process, understanding pain points for end customers regarding refurbishing versus remanufacturing, as well as developing green design for new products. Furthermore, it involves continuously working on expanding the take back system towards more repairs and reuse. When setting up these processes for reuse, it is recommended to make sure that the cost is built-in for the customer, similarly to how it currently works when products are repaired within warranty. One final long-term recommendation for the electronics manufacturer is to strengthen their sustainability image by enhanced collaboration with partners, as this is concluded

to have a positive impact on their long-term sustainability and profitability. The long-term roadmap is shown in Figure 16 below.

Aside from prioritizing solutions and implementing roadmap recommendations, it is important to assign the different areas of responsibility for an efficient transition and execution phase, also emphasized by Werning and Spinler (2020). Taking ownership and accountability of the take back program and the obstacles arising on the way also increases the likelihood of success for the implementation. Therefore, the electronics manufacturer needs to have designated employees for the needed areas, and despite trusting and collaborating with partners, they should not pass on responsibility for their decommissioned products.

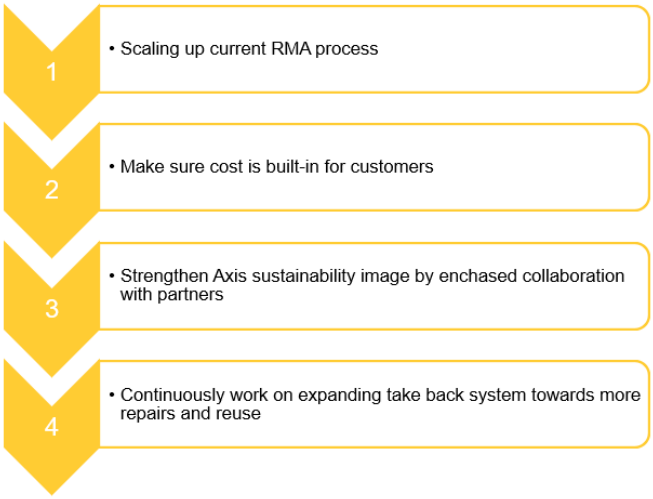

Figure 16. Axis long-term roadmap for establishing a take back system in the US.

Many of the above-mentioned recommendations and applied matrices could be used by a broader audience as well. For this, a generalized framework was developed to increase the transferability of the thesis. How other companies can make use of these findings, is presented below.

6.3 Generalized framework

The framework, developed based on data collected from Axis, can be transferred to and leveraged by a broader audience. Any electronics manufacturer wanting to implement a take back system can use the framework to identify barriers, and to find and prioritize solutions. Table 12 below visualizes the clusters and their causes with associated effects, which can be used as a framework to get an overview of the barriers. Further, Figure 12 above presents the Solution Evaluation Matrix that

should be used in step 4 below as a tool for prioritizing the solutions. The framework includes a seven-step process, described below.

1. Identify challenges related to the four clusters - Corporate strategy, Finance, The electronics manufacturer and upstream supply chain, and Downstream supply chain. Inspiration can be found from the compiled interviews in Table 10.
2. Determine, which barriers are higher level causes, and which ones are their effects. Inspiration can be found in Table 11.
3. Find solutions addressing each challenge identified in step 1.
4. Evaluate solutions solving the causes, identified above, based on their execution capacity and their impact on the implementation, and place them for each cluster in the Solution Evaluation Matrix.
5. When the solutions for the causes have been evaluated, redo step 4 for the solutions to the connected effects. Especially note the interconnection between all barriers.
6. Merge the solutions in the four upper right corners into one matrix. These solutions have the biggest impact and are easiest to carry out.
7. Create a roadmap with the prioritized solutions. Prioritize in the upper right corner by moving diagonally downwards from the upper right corner. Keep in mind the interconnection between the barriers.

Table 12. Generalized clustering of barriers and solutions.

Cause	***Effect***	***Solution***
Corporate strategy		
List the causes	List the effects	List the solutions
Finance		
List the causes	List the effects	List the solutions
The electronics manufacturer and upstream supply chain		
List the causes	List the effects	List the solutions
Downstream supply chain		
List the causes	List the effects	List the solutions

6.4 Future research

This thesis focuses on barriers for an electronics manufacturer to establish a take back system for their decommissioned products in the US. The aim was to understand the barriers from all stakeholders' perspectives in the downstream supply

chain, including the case company itself, something that is not frequently occurring in existing research.

Werning and Spinler (2020) observed the limited amount of research focusing on a firm level connected to transitioning to a circular economy. As far as the research made by the authors of the thesis shows, the majority of research articles take a system perspective and focus on possible governmental incentives, strengthening the findings made by Werning and Spinler (2020). This argues for a gap in research with regard to a firm-level approach. The thesis aimed to start bridging this gap, however exploring this area further would be valuable considering that the prerequisites differ when the government gives incentives compared to when a firm gives them.

Furthermore, understanding the end customers' point of view, but also the other parts of the downstream supply chain, is vital for an electronics manufacturer's success with the implementation, yet there is little research on this area. In the table summarizing barriers in previous literature (Table 2), there were only few barriers focusing on end customers' perspective in comparison to the number of challenges focusing on the company's perspective. Where research focuses on what the government can do to incentivize companies and consumers to start reusing and recycling, this thesis recognizes ways for a company to incentivize their end customers to recycle. This business to business (B2B) incentivization should be studied further.

Circular economy is a widely discussed topic today, and to make the loop circular, the reverse logistic setup is important. However, there are still few articles focusing on this practical part of closing the loop (Bernon et al., 2018; Esposito et al., 2018). The benchmark in this thesis is limited as it is only looking at companies' websites. One reason for this, is that there are few examples in academia for establishing take back systems and incentivizing end customers. The authors welcome more reports on the topic and a critical evaluation of the existing initiatives. In addition to addressing the logistics setup, the authors call for further research addressing the recycling process. Evaluating costs and the current efficiency at the recycling centers is vital to ensure a comprehensive and well-performing process and for companies to understand what costs and risks that are involved as well as what opportunities the process entails.

6.5 Limitations

As mentioned in Section 2.2, ensuring sufficient quality and academic excellence of the thesis was done using five aspects, namely *credibility, transferability, dependability, confirmability,* and *reflexivity*. The limitations and weaknesses of the research were determined through evaluation of these factors, and the most significant ones will be further elaborated upon below.

The *credibility* of this thesis could be questioned due to the limited amount of conducted interviews. The credibility of the research could have been higher with a larger number of interviews, to mirror the differences between customers, system integrators, and distributors but also to be able to map their similarities more accurately. Additionally, only one case company has been examined and with more different types of electronics manufacturers the results the credibility, but also the *transferability*, would have been greater.

Further, critique is presented against the *transferability* as it is dependent on the collected data. The data is collected in the US, and, therefore, it is hard to claim that global conclusions can be drawn from these results. On the other hand, the Barriers and Solution Evaluation Matrices were developed as general tools for companies struggling with implementation of take back systems.

Additionally, the *dependability* could be questioned as the interviewed people and their biases could influence the results, and it cannot be fully ensured that the exact same results would be obtained with different interviewees within the same selection group. *Confirmability* and *reflexivity* are closely linked, and a weakness related is the subjective placement of the barriers in the Solution Evaluation Matrix. Even if this placement is validated by multiple parties, there is still a possibility that another researcher would have obtained a different result.

There are shortcomings in every academic paper. This also applies to this thesis and these need to be reflected upon and evaluated, which has been done above. The shortage in the number of interviews, the fact that the study is made in the US and the fact that only one case company is examined are the most significant limitations in this thesis. Nevertheless, this thesis provides a good understanding of the challenges a firm faces when implementing a take back system.

7 Conclusions

In the final chapter the results, findings, and recommendations are summarized and the case company's and other electronics manufacturers' way towards circularity is reflected upon. The conclusion consists of this summary, but also a reminder of how the research questions have been answered to guarantee the validity of the thesis.

Axis' ambition is a transition to a circular supply chain and some existing initiatives, including this thesis, are promoting this work. As stated in Section 4.2, Axis already works with introducing recycled material in their products similarly to other companies. This can incentivize companies to find business opportunities within the recycling industry. In the same section, it is highlighted that Axis is working to eliminate hazardous substances, which facilitates the recycling of their products.

Axis has laid a good foundation, and now they want to implement a take back system for their own products. All in all, these initiatives are promoting the wish to transition to a circular economy. Even if this thesis focuses on recycling, later also reuse and remanufacturing can benefit from an existing and functioning reverse supply chain. As discussed above, Axis is on the way to kick-start their journey towards circularity. Even if the thesis is limited to recycling, the solutions recommended should, at least to some extent, support, or at least not hinder, future reusing, refurbishing and remanufacturing.

The aim of this thesis was to investigate the opportunities for an electronics manufacturer to introduce a take back system for decommissioned products in the US market, primarily for recycling purposes. As stated previously, the investigated research questions are (1) what are the possible barriers when introducing a take back system for electronics manufacturers? (2) what solutions can help an electronics manufacturer to overcome these barriers? and finally, (3) how should Axis Communications proceed with establishing a take back system? This thesis answers these questions, as mentioned below.

When summarizing insights from interviews several barriers were identified for an electronics manufacturer. These could be divided into four different clusters highlighting the overall categories affecting a take back system, see Table 11. Additionally, solutions to tackle the barriers were outlined, see Table 10. It was found that simplicity and low cost are critical success factors to get the downstream supply chain stakeholders onboard. Tangible benefits are suggested to increase their willingness to participate. Finally, a short- and long-term roadmap of

recommendations were laid out for Axis based on the prioritization of possible solutions. These roadmaps are presented in Section 6.2.

To sum up, this thesis contributes to theory by providing a unique case study with a B2B approach where stakeholders from the entire downstream supply chain have been interviewed. In addition to the academic contribution, the thesis contributes to practice by giving electronics manufacturers a good understanding of how they should move forward with establishing a take back system.

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Appendix A Interview information

Appendix A consists of a full list of interviewees and all the interview guides for distributors, system integrators, and end customers.

A.1 List of interviewees

Below in Table 13 all interviewed people are represented.

Table 13. List of interviewees.

COMPANY	*TITLE*
Distributors	
ADI	Indirect Sourcing Leader
Global Distributor	Global Senior Manager in Environmental Management & Sustainability
System integrators	
PDS	Business Development Executive
Convergint	Business Development Manager
System integrator	Strategic Sourcing Manager Technology Solution Manager
End customers	
Cypress-Fairbanks Independent School District	Security Technician
Industry experts	
Cascades	Vice President
Global electronics manufacturer	Senior Account Executive OEM Program Manager Business Developmenent EMEA
Internal Axis experts	
Reverse Supply Chain Director Global Service Manager Program Manager of Inside Sales & Channel Programs National Inside Sales Account Manager	

Environmental team	
Axis Key Account Managers	
ADI	Distributors
Global distributor	
PDS	
Convergint	System integrators
System integrator	
Cypress-Fairbanks Independent School District	
Walmart	
Facebook	
Tesla	End customers
Google	
Apple	
Koch Brothers	
Tyson	

A.2 Interview guides

A.2.1 Interview guide for distributors

Filtering questions (to be checked beforehand, interviewee should belong to predetermined selection)

- Do you sell Axis products?
- Do you work with environmental sustainability questions or feel like you have enough insight to be able to answer related questions on behalf of your company?
- Do you have insight into the supply chain within your organization?
- Do you work in the US market?

Comfort questions

- Tell us something short about yourself and your company, like the size of the company, industry and customer segment?
    - What kind of environmental sustainability work is done within the company, and do your tasks relate to sustainability?

Main part

<u>Relationship with Axis Communications</u>

- What is your relationship with Axis, and what is your image of Axis when it comes to environmental sustainability questions?

Relationship with Axis' end customers

- What is your relationship with end customers buying Axis products?
- Have you noticed any pressure or trends from end customers regarding environmental sustainability?
    - Any particular customer that comes to mind for their environmental sustainability work? Why?

Relationship with Axis' system integrators

- Are you selling to one or several system integrators when you are selling Axis products?
- What kind of relationship do you have with them(the ones they are selling to)?
- What is your image of system integrators when it comes to environmental sustainability questions?
    - Any particular system integrator that comes to mind for their environmental sustainability work? Why?

E-waste management

- What is your standard procedure for used electronics today?
    - What are the reasons for this procedure?
    - If they say that e-waste goes to landfill:
    - How much does it cost for you to ship and dump e-waste at a landfill?
- If any type of circularity such as reuse or recycling of e-waste:
    - What does that mean for the lifecycle management cost?
- If storage:
    - Do you have any estimates on the storage costs?

Recycling system/life-cycle management system

- Do you have any goals set for recycling electronics?
- What is your attitude to be a part of a system where decommissioned products are recycled?
    - How likely are you to take part in such a system?
- How do you see your role if Axis were to establish a take-back system for decommissioned products?
- What factors would enable your participation in any recycling system?
    - What would you expect from Axis for you to be willing to take part in such a recycling system?
- What opposition do you have towards participating in such a program? Why do you see these factors as barriers or risks?
    - Try asking for hard limits

- If we send end customers to you with their decommissioned products, how would that impact the life cycle management cost?
- *If needed: Do you have anything else to add when it comes to how the recycling system could and should look like?*

Conclusion

- Do you have any questions or anything else to add?
- Explain how the information will be used and the purpose of the report.
- Ask if it is okay to get back to the person afterwards if new questions arise.
- Ask if the name of the interviewee can be used in the report
- Thank the person for their time.

A.2.2 Interview guide for system integrators

Filtering questions (to be checked beforehand, interviewee should belong to predetermined selection)

- Do you sell Axis products?
- Do you work with environmental sustainability questions or feel like you have enough insight to be able to answer related questions on behalf of your company?
- Do you have insight into the supply chain within your organization?
- Do you work in the US market?

Introduction

- Thank the interview object for participating
- Presentation of interviewers and interviewees
- Presentation of purpose and scope
- Explain that it is voluntary to give the name of the company or not and that we at the end of the interview will ask if the name of the interviewee can be used in the report

Comfort questions

- Tell us something short about yourself and also your company?
    - Like the size of the company, industry and customer segment?
    - What kind of environmental sustainability work is done within the company, and do your tasks relate to sustainability?

Main part

Relationship with Axis Communications

- What is your relationship with Axis, and what is your image of Axis when it comes to environmental sustainability questions?

Relationship with Axis' end customers

- What is your relationship with customers buying Axis products?
- What is your image of your customers when it comes to environmental sustainability questions?
    - Any particular customer that comes to mind for their environmental sustainability work? Why?
    - Have you noticed that they are putting pressure on you when it comes to environmental sustainability?

Relationship with Axis' distributors

- Are you buying from one or several distributors when you are buying Axis products?
- What is your relationship with XX (the ones they buy from)?
- What is your image of distributors when it comes to environmental sustainability questions?
    - Any particular distributor that comes to mind for their environmental sustainability work? Why?

E-waste management

- When selling a new installation to a customer, how likely is it that you decommission and take care of the old products?
- What is your standard procedure for used electronics today?
    - What are the reasons for this procedure?
- If they say that e-waste goes to landfill:
    - How much does it cost for you to ship and dump e-waste at a landfill?
- If any type of circularity such as reuse or recycling of e-waste:
    - What does that mean for the lifecycle management cost?
- If storage:
    - Do you have any estimates on the storage costs?

Recycling system/life-cycle management system

- Do you have any goals set for recycling electronics?
- What is your attitude to be a part of a system where decommissioned products are recycled?
    - How likely are you to take part in such a system?

- How do you see your role if Axis were to establish a take-back system for decommissioned products?
- What factors would enable your participation in any recycling system?
    - What would you expect from Axis for you to be willing to take part in such a recycling system?
- What opposition do you have towards participating in such a program? Why do you see these factors as barriers or risks?
    - Try asking for hard limits
- *If needed: Do you have anything else to add when it comes to how the recycling system could and should look like?*

The different alternatives:

System 1: Active role: decommissioning and bringing products to recycling centers.
System 2: Passive role: The collection and delivery to a recycling center is done by a third party.
System 3: In between: Decommissioning and collecting products, and then a third party is picking up the decommissioned products and bringing them to a recycling center.

Conclusion

- Do you have any questions or anything else to add?
- Explain how the information will be used and the purpose of the report.
- Ask if it is okay to get back to the person afterwards if new questions arise.
- Ask if the name of the interviewee can be used in the report
- Thank the person for their time.

A.2.3 Interview guide for distributors

Filtering questions (to be checked beforehand, interviewee should belong to predetermined selection)

- Do you possess Axis products?
- Do you work with environmental sustainability questions or feel like you have enough insight to be able to answer related questions on behalf of your company?
- Do you have insight into the supply chain within your organization?
- Do you work in the US market?

Comfort questions

- Tell us something short about yourself and also your company?
    - Like the size of the company, industry and customer segment?
    - What kind of environmental sustainability work is done within the company, and do your tasks relate to sustainability

Main part

Relationship with Axis Communications

- What is your relationship with Axis, and what is your image of Axis when it comes to environmental sustainability questions?
- To get an understanding of the potential environmental sustainability impact that your company can have in Axis supply chain, we are wondering:
    - How many Axis products do you have today?
    - Do you have a picture of the share of Axis products compared to the total amount of surveillance products you have?

Relationship with Axis' partners (system integrators & resellers)

- Via which channel are you buying your Axis products?
- What is your relationship with XX (the ones they buy from)?
- What is your image of resellers/system integrators when it comes to environmental sustainability questions?
    - Any particular reseller/system integrator that comes to mind for their environmental sustainability work? Why?

E-waste management

- What is your standard procedure for used electronics today?
    - What are the reasons for this procedure?
    - Is the procedure standardized or free for employees to choose the best alternative?
        - How is the process documented specification for this that we would be allowed to take a look at?

If they say that e-waste goes to landfill:

- How much does it cost for you to ship and dump e-waste at a landfill?

If any type of circularity such as reuse or recycling of e-waste:

- What does it cost? Do you have any estimates?

If storage:

- Do you have any estimates on the storage costs?

Recycling system/life-cycle management system

- Do you have any goals set for recycling electronics?

- What is your attitude to be a part of a system where decommissioned products are recycled?
    - How likely are you to take part in such a system?
- How do you see your role if Axis were to establish a take-back system for decommissioned products?
- What factors would enable your participation in any recycling system?
    - What would you expect from Axis for you to be willing to take part in such a recycling system?
- What opposition do you have towards participating in such a program? Why do you see these factors as barriers or risks?

Axis wants to be more environmentally sustainable, but we need to cooperate with our partners and customers to do so. In this thesis, we focus on these aspects. We have seen in literature that disposal costs around USD 150-250 per ton and recycling USD 400-1000 per ton. In this thesis, we do not have the authority to set a specific price, but we are interested in how and when to pay and how to share the risk.

- If Axis or our partners would create a circular process, would it be ok if it came with a cost impact? (Would you be willing to pay to be a part of a recycling system?)
- Would it be ok if the total cost of ownership for the product would be higher if you knew that the product will be properly recycled at the end of its life?
- How does the IT department deal with decommissioning today from a time frame and service agreement perspective?
- (Do you have any other suggestions for how and when to pay for such a system?)
- Based on what we have talked about now, has your attitude towards a take back system changed or remained the same? What is your attitude towards taking part in a take back system?
- *If needed: Do you have anything else to add when it comes to how the recycling system could and should*

.

Explaining the different alternatives:

System 1: Full service, Axis comes to pick up their decommissioned products and make sure they are recycled, but this comes with a fee.
System 2: Partial service, You arrange the transportation to a collection point and Axis make sure the collected products are recycled.
System 3: If the interviewee suggests another alternative for the pricing model

Conclusion

- Do you have any questions or anything else to add?
- Explain how the information will be used and the purpose of the report.
- Ask if it is okay to get back to the person afterwards if new questions arise.
- Ask if the name of the interviewee can be used in the report
- Thank the person for their time.

Appendix B Evaluation of solutions

Appendix B includes a detailed justification of the solutions' placement in the Solution Evaluation Matrix for the three clusters; Finance, The electronics manufacturer and upstream supply chain, and finally Downstream supply chain.

B.1 Solutions evaluation

In Section 5.3, the Solution Evaluation Matrix was described. Further, the application of the matrix with the placements of all the solutions within the Corporate strategy cluster were elaborated upon. Below follows a continuation of that chapter where the same analysis is done for the remaining three clusters.

In the Finance cluster the potential solutions, focusing on the cause, short-term profitability requirements, and its effects, are evaluated and can be seen in Figure 17. It was assessed that having a *long-term focus and accepting an increased risk,* when it comes to environmental initiatives, would have a large impact on the implementation of the take back system. However, it is argued that an electronics manufacturer would have a medium to low capacity to influence this, since the financial goals are determined by external shareholders.

The short-term profitability requirements are argued to explain the weak top management support. The authors suggest that this can be solved by a *well-thought-out business case*. Presenting a viable, feasible and desirable business case to the board would have both a fairly large impact on the implementation, but would, thanks to the fact that it is detailed, also be possible to execute fairly easily. This is of course easier said than done, and formulating such a business case takes time, effort, and experience and will still involve a certain level of uncertainty.

To define a viable business case, it might be necessary to understand what currently is measured and what the purpose of the business case is. The electronics manufacturer itself has the power to decide on what is internally measured, and therefore, the manufacturer is assumed to have quite high possibilities to *review the current KPIs.* Further, this solution is estimated to have a medium impact on the implementation, due to the changed meaning of what successful and profitable initiatives look like. The authors recommend putting together a project group with members from different departments who should, with support from the board,

address what is currently measured and why this is a result of the short-term profitability requirements, but also the current linear mindset. They should evaluate how KPI measurements can be made different in the future to give sustainability efforts a fair ranking.

Since cost still will have a big impact, even if the KPIs are adjusted, the electronics manufacturer should address the fact that designing, implementing, and managing a take back system will require resources by *planning for minimized costs*. Because the take back system is a cost-only program, it is concluded that minimized costs will have a high impact on the implementation. As mentioned in interviews, there are possibilities to find fairly easy ways to cut costs. However, the execution capacity is evaluated to be medium due to the limited number of recycling initiatives in the world. Nevertheless, allocating resources is necessary for proper execution of an initiative.

Additionally, accepting *lower returns on the investment* (ROI) is established to have a quite high impact on the take back system but a low ability and willingness to execute for electronics manufacturers. It is seen as unrealistic for a board to suddenly start accepting worse performing projects to be further prioritized. However, this idea of what terms a project is profitable and successful will be altered once the KPIs are reviewed and adjusted to address sustainability questions. Moreover, will returns on investment occur in other ways such as through an increased brand value and popularity which can lead to higher market capitalization of a company as a result of circularity initiatives.

The risk of *cannibalization* of current sales is a future concern when taking the step from recycling to reuse of products. It is, however, substantial enough to address already in the recycling phase, but overall have a smaller impact on the take back system as it is currently planned with recycling only. This aspect is in the electronic manufacturer's hands to influence, making the execution capacity fairly high.

If the fear of cannibalization would be overcome, there would still remain a challenge whether there is a secondary market to resell products or not. To tackle this uncertainty, the electronics manufacturer should *conduct a secondary market analysis*. With assumed experience of conducting analysis when entering new markets, it should be possible to do one for the secondary market. Consequently, this is determined to be something fairly easy to execute, yet with a smaller impact on the implementation as this thesis focuses on recycling and not reuse.

As mentioned, the case company does not today have control over their products after they are sold, and thereby they also do not control any potential secondary market. This is probably true for a majority of the electronic manufacturers, but it needs to be underlined that this can differ. There are some examples and indications that the gray market is increasing in size. With no control, the electronics manufacturer can also not prevent sales through unauthorized distribution channels from happening. It is, therefore, suggested to, in the future, to embrace this trend and to start making profit of it rather than seeing cannibalization as a risk. It

has been said that alternatives are either that the electronics manufacturer makes profit on the secondary market or that someone else does it. This is, however, many stages away and how to do this is out of scope for this thesis.

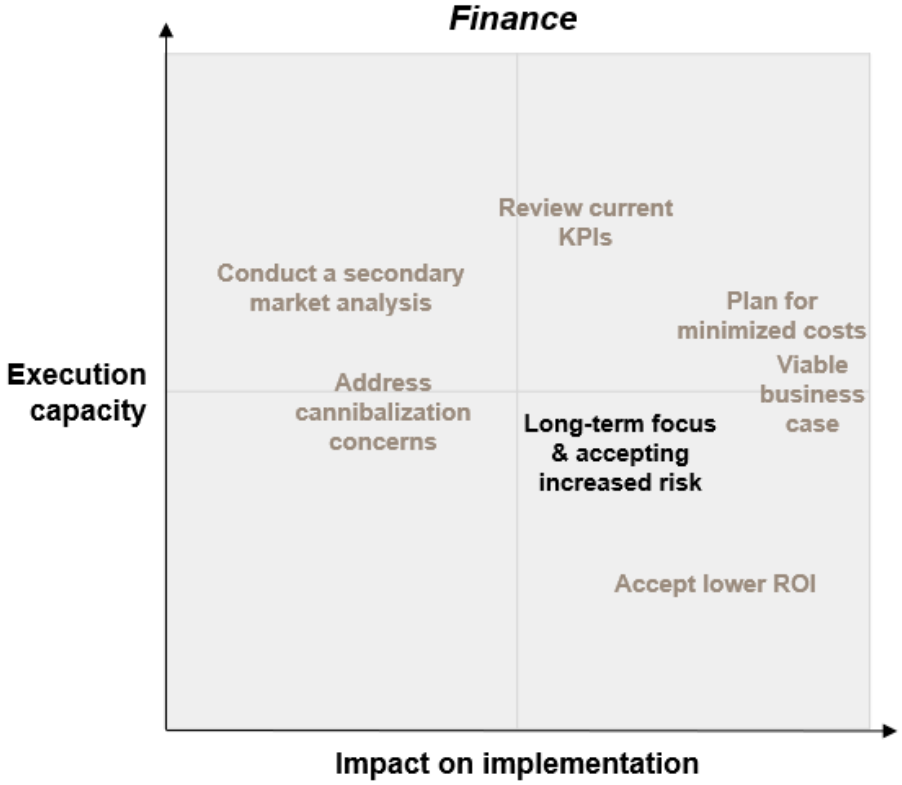

Figure 17. Potential solutions, focusing on the short-term profitability requirements.

The solutions proposed to the barrier of limited reverse logistics organization, and to the related effects in the cluster, the electronics manufacturer and upstream supply chain, are assessed and placed in the Solution Evaluation Matrix, see Figure 18 below. Assuming an electronic manufacturer has some kind of RMA process, like the case company, the limited reverse logistics organization is suggested to be solved by *expanding the current RMA process* and not only include repairs, but also taking back products for recycling. By using the RMA process, the products will come back to electronics manufacturers' ownership, unlike when outsourcing this to a recycling service provider taking the products directly to a recycling center. This will in other words facilitate future work striving for improvements in reuse.

However, input from interviews suggested that using the current RMA process would mean that other electronic equipment, in addition to electronics manufacturer's products, might be sent back. This could be a challenge compared to outsourcing to a RSP, since an electronics manufacturer does not in the same way have the capacity or competence of handling large volumes of different kinds of

electronics. Regardless, the case company is considered to have substantial possibilities to expand the current RMA process, implying high execution capacity. Further, the logistics around the take back system is a critical success factor, which is why the impact on implementation is valued as high.

Furthermore, studies show that the profitability of the whole supply chain can be increased with a centralized setup (Ghalehkhondabi & Ardjmand, 2020). This, together with the advantages for future circularity work, support the alternative of using the current RMA process, and thereby establishing a centralized decision making. However, one important environmental consideration is to minimize transportation. By using the RMA process, there is a risk that products are transported back only to be recycled by the electronics manufacturer, leading to unnecessary transportation. To tackle this the electronics manufacturer should in the future establish troubleshooting on site, which potentially could be done by system integrators, to determine if the products should be sent back to the RMA center for reuse or be recycled directly. Synergies with the ambitions for increased number of on-site repairs can likely be found within this area.

No experience in the field is another challenge and can be handled by *outsourcing the services* related to a take back system to take advantage of systems already in place and working. There are several reasons why the execution capacity is estimated to be high. Firstly, according to the environmental team, the case company has many partners wanting to work with them in this area. In the benchmark, Section 4.4, there are several examples of partners they could learn from. The initiatives are made within the broader electronics industry, mainly outside of the case companys' own surveillance industry. As these companies are not directly competitors, synergies could benefit all involved parties. Secondly, this will require less effort from them in comparison to expansion of the current RMA process.

Lastly, as a manufacturing company they should focus on their core competencies, as stated by an industry expert in Section 5.1.5, and not on recycling service activities. Using a centralized service means that an electronic manufacturer can benefit from the fact that a RSP can gain cost advantages thanks to economies of scale. These are three arguments why it is considered to be easier to outsource the services than expanding the RMA process for an electronics manufacturer. As mentioned above, the logistics is significant, and it should, therefore, have the same impact on the implementation as expanding the RMA process. However, if all recycling services are outsourced, with the argument that these questions are outside the core competence, an electronics manufacturer will not build up the needed competences, to become a fully circular organization. This further emphasizes that expanding the current RMA process should be evaluated as well.

Even if an electronics manufacturer chooses to outsource the recycling service, they are still liable towards their end customer and are responsible for the correct handling of their product. By *guaranteeing proper handling of their products*, they manage these liability concerns. This is done by requiring certain certifications of

their partners. Two good recommendations made by experts are R2 and e-Steward. Further, it is important to evaluate end customers' perception of the trustworthiness of these standards and recyclers, as their participation is a prerequisite to introduce a take back system.

To be able to find an agreement with partners, it is preferable to specify the capacity needed. This can be difficult due to the uncertain collection demand. However, it is suggested to be handled by *developing a forecasting tool for decommissioned products*. The case company already has a solid forecasting tool for demand patterns, which indicates that it should be fairly easy for them to develop a forecasting model for decommissioned products returning to them. Although a reduced uncertainty in collection demand would be beneficial, it is not considered to be that critical for the implementation of the take back system.

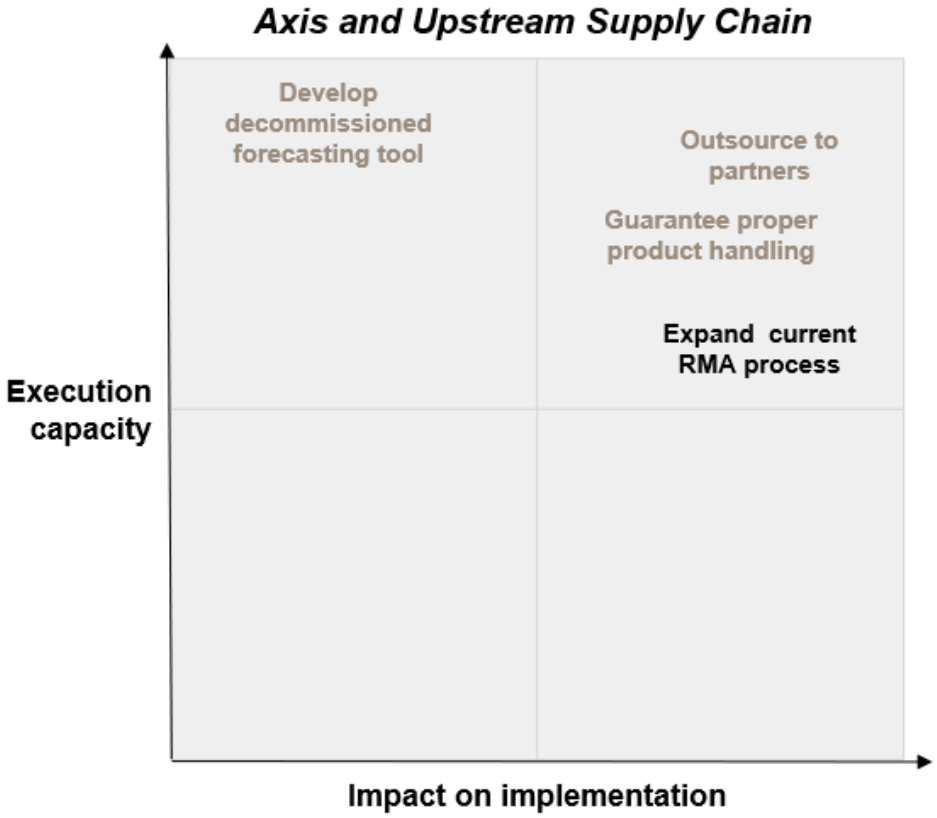

Figure 18 Potential solutions, focusing on limited reverse logistics organization.

The solutions within the Downstream Supply Chain cluster are evaluated based on the execution capacity and impact on implementation, shown in Figure 19. The barrier of risk aversion towards new initiatives for stakeholders in the downstream supply chain is essential to overcome, since the case company does not have the

ownership of the products. This should be overcome by *increasing the collaboration and knowledge sharing within a partnership program*. If there is a partnership program in place, like the existing CPP for the case company, it could be beneficial to take advantage of it. A partnership program can promote and coordinate common sustainability ambitions, leading to all parties striving towards the same goals. What needs to be mentioned is the importance of preserving the integrity of the different levels within a certain partnership program. This implies that even if a recycling reporting system is integrated to an existing program, it should not influence the levels for a certain partner.

As mentioned previously, a centralized setup can increase the profitability of the supply chain. However, there might be issues with the division of these profits, which is why collaboration and trust are both essential to even out these differences (Ghalehkhondabi & Ardjmand, 2020). A partnership program is a way to share risks, and hence increase the trust between the collaborators. An electronics manufacturer has the power to implement a partnership program encouraging recycling procedures, however, there are difficulties regarding how the program should be designed. Although a partnership program would increase the incentives to return decommission products, it would only have a medium level impact on the implementation of the take back system, since a partnership program is less related to the practical setup and a system could in theory be implemented without the program.

The fear of increased workload can be managed by implementing a *seamless procedure.* It is concluded from interviews that an easy procedure is critical for downstream supply chain partners' participation in the take back system. Ideas brought up to create a seamless procedure are some kind of labels or QR codes that the end customer or system integrator could use to return the decommissioned products. The authors argue that this should be possible for an electronics manufacturer to implement, however, there are some concerns about, for example, how this should work and who should pay for the transportation. In relation to the fear of increased workload, there is also a resistance towards increased costs as a result of a take back initiative. The downstream partners are not willing to pay extra for an additional recycling service, which is why they suggest a built-in recycling cost within the existing offer.

Further, the fact that the decommissioned products still have a value is seen as a barrier. It is suggested that incentives can help overcome both the barrier for increased workload and barrier for increased costs. Interviews revealed that some kinds of incentives are equally important as a seamless procedure. It is recommended to use reward incentives, rather than penalties, since they are an efficient way to encourage a certain behavior. Song and Chu (2019) see a positive impact when governments give incentives to consumers and companies. Drawing the same conclusion when a company, in this case an electronics manufacturer, incentivizes their end customers, is determined to be a valid adoption of theory.

Additionally, a higher intensity of the rewards is recommended to achieve higher recycling rates for a manufacturer (Song & Chu, 2019). Encouraging recycling behavior by rewarding often could be used by an electronics manufacturer as well. However, this reward system will be even more profitable once the next step, reuse, is considered, since the system then can start generating revenue. Since the take back system, as it is planned in this thesis, is primarily focusing on recycling, it is a cost only program. This makes it difficult for an electronics manufacturer to offer economic incentives for the partners. When considering the case company, it was found that the non-existent financial relationship between Axis and their system integrators and end customers restricts the use of economic incentives. For electronic manufacturers that only have indirect sales it is therefore initially advised against price-discount incentives, even if Song and Chu (2019) recommend it.

However, there are other incentives to be considered like giving free products or free education on the electronics manufacturer's products, for example. Previously, internal experts mentioned an idea with regular reviews on recycling rates. If the system integrator exceeds a certain threshold value, they would get some tangible benefits from Axis. This incentivizes the system integrator to recycle thanks to the benefits, but also because they can use the report for marketing purposes. The review should be on a quarterly basis rather than on a half year basis, in correspondence with theory, suggesting high reward intensity. This process needs to be automated to keep the administrative workload low for all parties. Further, the authors of the thesis argue that any electronics manufacturer can apply this review on recycling for measuring behavior and rewarding partners accordingly.

Another concern is cyber security, which could be solved by *hiring certified recycling partners*. This concern can be a major barrier for some end customers, which is why the solution has a high impact on the implementation. Further, it is concluded that this is a straightforward solution for the electronics manufacturer, meaning easy to execute. As a result of the cyber security concerns, among other things, the downstream supply chain stakeholders do not prioritize recycling efforts today. This can be handled by education and *demonstration of environmental impact* for them. The authors argue that if these stakeholders were to understand the positive environmental impacts of circularity, partaking in a take back initiative would be seen as more interesting. This implies a fairly high impact on implementation. Yet, it is discussed that it is very difficult to reach that level of understanding, which is why the execution capacity is estimated to be low.

Related to this low priority, one common finding in all interviews was that the downstream supply chain partners were neither familiar with nor particularly interested in Axis sustainability work. This implies a need for more work and closer collaboration with partners in the sustainability area to achieve both better results for the environment and recognition as a sustainable brand. In general, electronics manufacturers should even further view a strong sustainability brand as a complement and possibility rather than a threat to the current brand. This might open doors to new end customer segments and long-term economic sustainability.

These findings above show how important it is to prioritize partners in relation to how willingly they are to partake in different recycling initiatives depending on geographical locations. Therefore, it can be beneficial for the take back initiative to *allocate the initial focus according to where the interest is the highest*. It is estimated that allocating the focus to where the interest is high is easy for an electronics manufacturer and is in their interest to do, which imply a high execution capacity. Further, it is suggested to have a medium impact on the implementation, since starting in an area with high sustainability interest will make it easier to get the starting group of partners onboard. However, this solution has only little impact on the take back system.

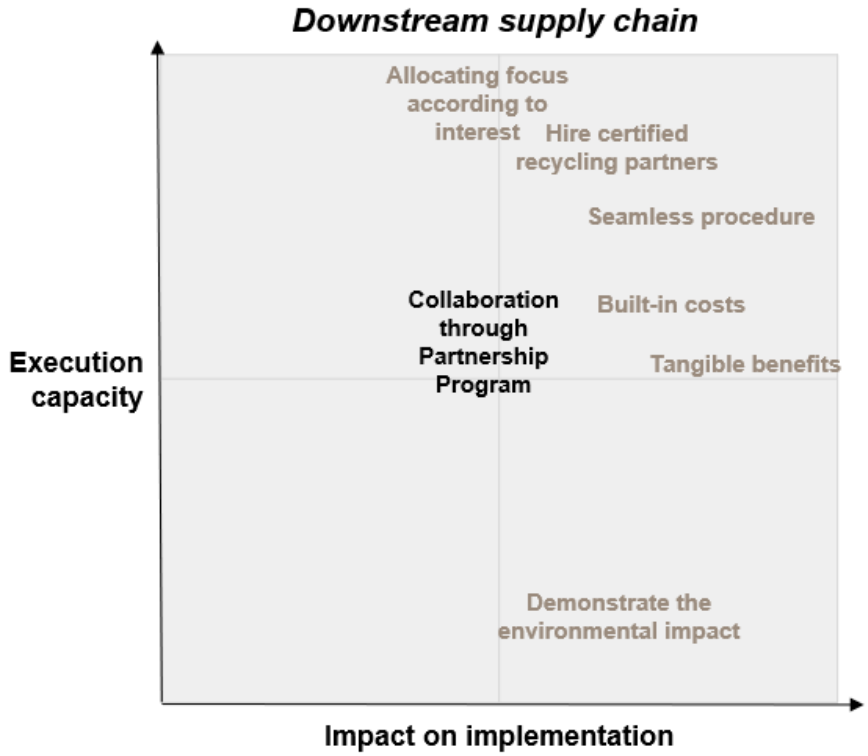

Figure 19. Potential solutions, focusing on the stakeholders' risk aversion towards new initiatives.