Packaging Decision-Making for Sustainable Supply Chain

A case study at Axis Communications AB

Akhil Varma Koneti and Vinay Vilas Thakur

DIVISION OF PACKAGING LOGISTICS | DEPARTMENT OF DESIGN SCIENCES
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MASTER THESIS

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Lund, May 2024

Akhil Varma Koneti and Vinay Vilas Thakur

Abstract

This master's thesis explores the objectives of packaging regulations and translates them into guidelines for a company's packaging decision-making process. The thesis was done in collaboration with Axis Communications AB, where the current packaging practices were analyzed. This was followed by analyzing the requirements of packaging regulations in the EU (such as PPWD and upcoming PPWR) and other major economies, and finally proposing guidelines for integrating these regulatory requirements into the company's operations.

First, a single case study of Axis was conducted to analyze current practices and shortcomings by integrating stakeholder interviews and archival data. A lack of cohesive strategy in packaging decisions is identified, emphasizing the need for packaging guidelines for the suppliers.

Second, the regulatory landscape was reviewed, focusing on the EU's role in promoting a circular economy. The review highlighted the global shift towards sustainability, mainly aimed at waste reduction and encouraging reuse and recycling.

Lastly, guidelines were proposed to Axis to integrate these into its packaging decision-making process. Inspired by the 9R framework for circularity, the guidelines will tackle scope 3 emissions with a target of 2030. Recommendations for implementation include supplier collaboration, life cycle assessments, and incentivizing sustainable practices. These proactive measures will position Axis as a leader in packaging sustainability, setting a benchmark for the industry.

Keywords: PPWD, Packaging Guidelines, Science Based Targets, Packaging decision-making.

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List of abbreviations

B2B	Business to Business
CLC	Configuration and Logistics Center
EMS	Electronic Manufacturing Services
EPR	Extended Producer Responsibility
EU	European Union
FSC	Forest Stewardship Council
GHG	Greenhouse Gases
LCA	Life cycle assessment
OECD	Organization for Economic Co-operation and Development
PPWD	Packaging and Packaging Waste Directive
PPWR	Packaging and Packaging Waste Regulations
PRO	Producer Responsibility Organization
REACH Chemicals	Registration, Evaluation, Authorization, and Restriction of
SBT	Science-Based Targets
SBTi	Science Based Targets initiative
UoA	Unit of Analysis

1. Introduction

This chapter provides context for this master's thesis and identifies the topic at hand. Furthermore, the introduction chapter discusses the purpose and research objectives, followed by the master's thesis's focus and delimitations.

1.1 Background

As the world moves towards a more sustainable future, industries and the government are initiating and enforcing mandatory regulations to curb the impact on the environment. Governments at all levels and in all regions of the world are recognizing the importance of addressing the challenge of sustainability (Bell, 2002). It is important to factor the global context into the domestic policy agenda. Businesses must take the lead; the government's role should be to encourage and create a sense of direction to achieve the purpose. According to some business leaders, only business and industry can lead toward sustainability quickly and effectively (McKinsey & Company, 2022).

An area of sustainability that is receiving increased attention is packaging and the waste generated by it. Packaging plays a crucial role from the time a product is developed to the time the product is fully consumed. Packaging can be viewed as a system with three interrelated packaging levels. These are primary packaging, which is often the sales packaging, secondary packaging which contains a certain number of primary packages and finally tertiary packaging which contains several secondary packages (Pålsson, 2018). Any packaging system should fulfill six basic functions, these are protection, containment, apportionment, unitization, communication, and convenience (Pålsson, 2018). Packaging affects the whole supply chain. From a business point of view, the packaging system is becoming an increasingly more vital and integrated factor for success in the marketplace. The influence of the packaging system is channeled through an efficient supply chain to add value and satisfy

steadily increasing customer demands (Olsmats & Dominic, 2003). The lifecycle of packaging is depicted in Figure 1.1.

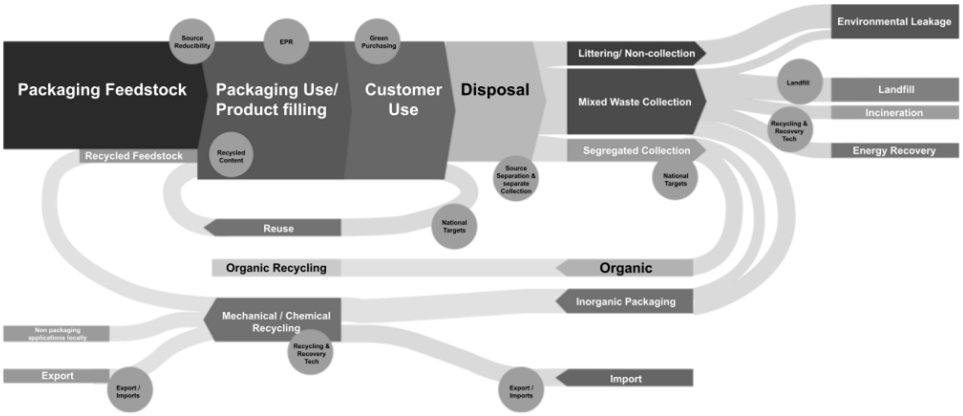

Figure 1.1: Lifecycle of Packaging (UNEP, 2019)

According to data on packaging waste published by Eurostat, the European Union generated huge quantities of packaging waste in 2021. **Each person in the EU produced about 188.7 kg of packaging waste**. That's 10.8 kg more per person than in 2020, the **biggest increase in a decade** (Eurostat, 2023). In 2021, the EU generated 84 million tonnes of packaging waste, with paper and cardboard making up 40.3% of it, plastic 19.0%, glass 18.5%, wood 17.1%, and metal 4.9% (European Parliament, 2023).

Pressure to reduce packaging waste has increased dramatically and regulators are responding to address these worries. In recent years, a rapid increase has been seen in sustainable packaging regulations and it is critical for companies across the value chain to be aware of the accelerating pace of regulatory development (McKinsey & Company, 2022), as non-compliance could lead to penalties. Companies are trying to incorporate these regulations into their internal compliance.

Initially, businesses saw environmental obligations as an added cost and were reluctant to go beyond compliance while often actively campaigning to minimize environmental regulation. Companies need to embrace sustainability principles and practices to increase both shareholder and stakeholder value. Companies committed to sustainability are using supply chain management to further their interests, expanding their scope across the value chain. Reduced material and energy, and

reduced waste generation can result in enhanced efficiencies. Efforts to identify opportunities for improving sustainability performance can result in a more proactive approach.

1.2 Core Issues

The Packaging Market size is estimated at USD 1.14 trillion in 2024 and is expected to reach USD 1.38 trillion by 2029, growing at a CAGR of 3.89% during the forecast period 2024-2029, source (Mordor Intelligence, 2024). The use of packaging is almost an irreplaceable part of any product nowadays. The packaging acts as a silent salesman for the company's products and conveys the brand to consumers, which is indeed one of the features of packaging among others. Packaging must contain and give enough protection to the product during handling and transportation throughout various logistics activities. While doing so, companies might fall for overpackaging and overprotection. Apart from these, packaging also needs to be convenient to handle, and sizes and unitization must be optimized for better use of resources. Often balancing all these factors and bettering all of them is overwhelming for companies and some factors may be neglected.

Although packaging is important for any product, it is the first thing that gets discarded after product use. Once a product is unpacked, this packaging becomes ‘Waste’. As per The World Bank statistics, packaging waste is the 2nd largest after food & green waste. Paper and plastics, among other packaging materials, are together responsible for 17% and 12% of municipal solid waste respectively. While managing this waste, only 13.5% of waste gets recycled (The World Bank, 2018). To tackle this issue of controlling and managing waste, governments, and organizations across the globe are working and creating various directives, regulations, and laws.

In recent years, there has been a rapid increase in sustainable packaging regulations well beyond a focus on shopping bags and selective food service items. Packaging-waste management is subject to one of the highest number of regulatory measures worldwide; 91 in total (McKinsey & Company, 2022). These regulations prioritize packaging's essential functions while also focusing on improving design and decision-making. They are not just about sustainability. Improved packaging can help avoid product waste, and waste management may be made simpler if the packaging is managed properly when it comes to its end of life. Even though this field is highly complex, it is nonetheless significant. Environmentally efficient

packaging is therefore necessary in current times. Therefore, it is crucial to investigate how businesses' packaging systems respond to existing requirements and where in the supply chain these regulations are most relevant. To achieve this, it is crucial to first comprehend the nature of these regulations and guidelines as well as how they solve this problem.

A thorough grasp of a company's greenhouse gas (GHG) emissions is necessary for developing an effective corporate climate change plan. Up until recently, businesses had concentrated on their own operations' emissions under the GHG Protocol's Scope 1 and Scope 2 (GHG Protocol and Carbon Trust & World Resources Institute, 2013). Businesses are realizing more and more that to handle GHG-related risks and opportunities fully, they must also take into consideration GHG emissions along their value chains and product portfolios. Hence this thesis focuses on the Science Based Targets initiative (SBTi, n.d.) to address emissions under Scope 3, which are those emissions that occur along a company's value chain. Supplier engagement and waste reduction are primary areas of focus for this research, as they not only contribute to environmental sustainability but also lead to lower costs, improved reputations, and ultimately ensure the long-term viability of both the company and its suppliers.

Axis Communications AB, hereafter Axis, is an appropriate case company to investigate these connections because of its presence in the EU, the Americas, and Asia. Since Axis is a relatively new company, its packaging system is still in its early stages of growth. This presents an opportunity to examine the connections between legislation and packaging systems, as Axis strives to be proactive when it comes to sustainability.

1.3 Purpose & Research Questions

The purpose of this research is to explore the packaging regulatory landscape and identify the challenges, gaps, and opportunities that will lead to the formation of packaging guidelines. This will provide a clearer view to navigate and comply with the requirements while describing the packaging decision-making process.

The purpose is addressed through the following research questions:

RQ1: What are the packaging decision practices currently being employed at the case company?

RQ2: What are the objectives and requirements of the packaging regulations implemented in the EU and other major economies, and how do they compare?

RQ3: How can the case company integrate these regulatory requirements into its packaging decision-making process?

1.4 Goal

The goal is to propose packaging guidelines that can be used as a frame of reference by the case company and inspire other business-to-business (B2B) electronics companies to comply with packaging regulations in the EU and other prominent markets. This can be imagined in the following illustration in Figure 1.2.

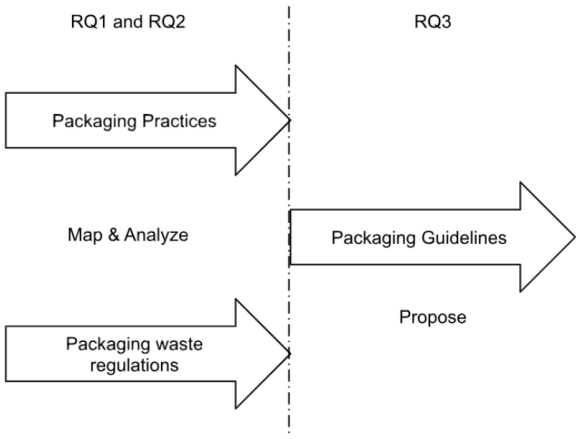

Figure 1.2: Purpose and research objective illustrated

1.5 Focus and delimitations

The focus of this thesis is narrowed down with the following three delimitations. First, the study is only concerned with restrictions that are directly relevant to the packaging used by electronics manufacturers, rather than all types of packaging categories to which regulations apply. Second, packaging activities upstream of the supply chain are in focus, considering them often neglected during product development (Chan et al., 2006). Third, due to the limited time frame of the thesis,

neither implementation of a proposal is done, nor given attention to the implementation plan for the same.

1.6 Thesis Outline

Chapter 1: Introduction

This chapter serves as an introduction to the academic report, offering necessary background information and explicitly outlining the research problem. The purpose, goal, and outline of the thesis are also described.

Chapter 2: Methodology

This chapter describes the study's research strategy and approach, with a focus on the methodology utilized and its relevance to the research aim.

Chapter 3: Frame of Reference

This chapter presents the theoretical framework as well as analytical sources to help the investigation. A thorough examination of relevant literature is conducted to build a fundamental notion for the investigation.

Chapter 4: Axis Case Study

This chapter evaluates the Axis' packaging decision-making process, mapping interactions between supply chain actors to understand the packaging practices.

Chapter 5: Regulatory analysis and review

This chapter examines regulatory frameworks and compliance strategies across various markets. It will explore potential upcoming regulatory changes and their impact on future practices and operations.

Chapter 6: Guidelines and Implications

This chapter will use the findings to propose guidelines for the case company's practices while addressing regulatory implications.

Chapter 7: Conclusion and Future Scope

The conclusions chapter will summarize the findings, analysis, and guidelines presented in the thesis. The purpose along with the research objectives will be revisited. Limitations of the thesis and future research areas will be discussed.

2.Methodology

This chapter will detail the research methodology chosen, the reason for selecting the specific research approach, as well as its constraints and limitations. To begin, a discussion to understand the basic research needs will be followed by the research framework. This will provide a better grasp of the process. To ensure the accuracy of the data supplied, this chapter will conclude with data credibility.

2.1 Research Strategy

Choosing the correct research strategy is very crucial in any kind of research (Creswell & Creswell, 2023). There are various kinds of research methodologies with varied purposes. So, to choose the perfect one, it is first important to understand the phenomenon (Voss et al., 2002); i.e. what is being studied, in what context, and for what purpose. Whether the research is qualitative or quantitative, there exists a multitude of rationales for its undertaking, such as formulating a hypothesis, validating it, engaging in innovation, or pursuing redesign.

Here, one of the units of analysis is packaging regulations within the EU along with other major markets to understand their underlying need. The reason to study them is to observe how these regulations influence the electronics manufacturing companies in their packaging practices and draw some conclusions, and how they can absorb this regulatory influx. This requirement itself is an exploration of the regulatory environment in different areas and at different levels within. Considering the regulations, these are always updating and changing in nature, hence there is some uncertainty associated with respect to the knowledge. Therefore, research in this area can take an exploratory form and is good for hypothesis creation. This is well explained in the ‘Maturity cycle of research’ (Malhotra & Grover, 1998) as shown in Figure 2.1. The curve suggests it is a good idea to conduct case research when certainty is low with respect to knowledge and when being early in the

timeframe. Hence this study can use a research strategy focused on exploratory research such as case research.

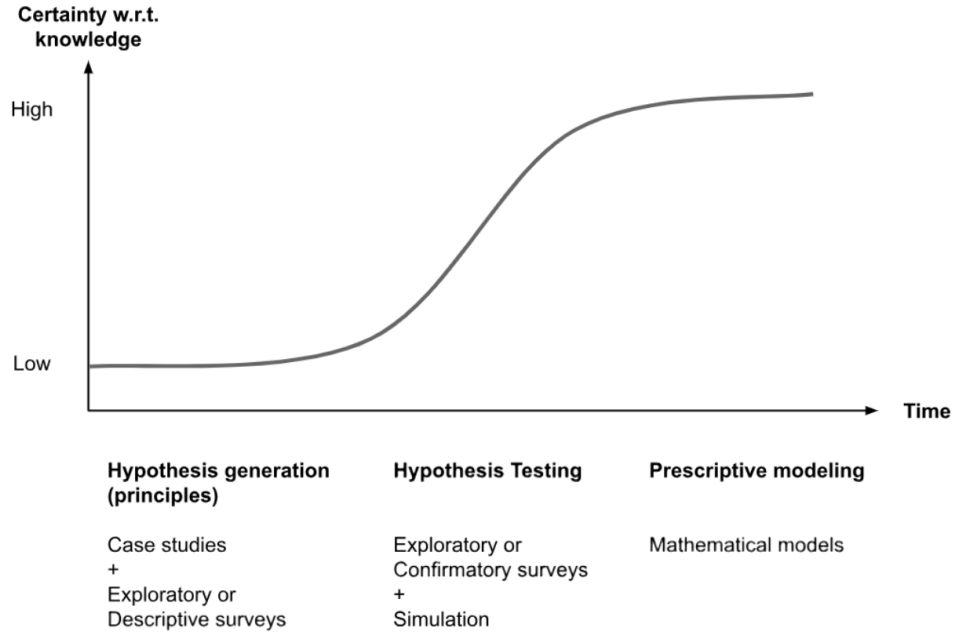

Figure 2.1: Maturity cycle of research (Malhotra & Grover, 1998)

A taxonomy of empirical research presented by Fisher (2007), depicted in Figure 2.2, can help to understand how one can choose a research strategy based on the goal of research and interaction with the world. In this study, considering data to be less structured and the goal to be more descriptive, the case study suits well here. This model confirms the choice of research chosen for this study.

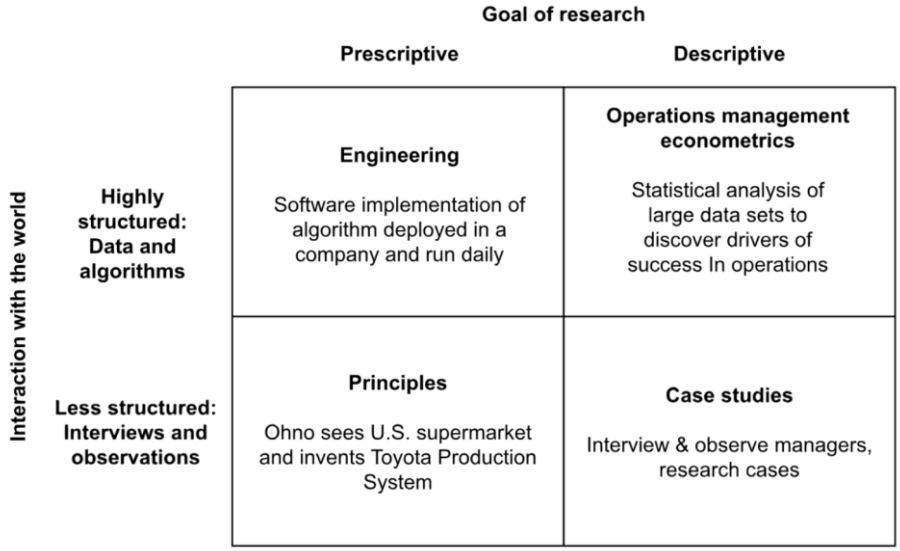

Figure 2.2: Empirical Research in Operations Management (Fisher, 2007)

A case study is an in-depth examination of a particular individual, group, situation, event, or phenomenon within its natural setting. Investigating the selected case or cases through empirical inquiry involves addressing the questions of "how" or "why" regarding the phenomenon of interest (Yin, 2002; Voss et al., 2002). While case research provides various advantages, it also has some disadvantages. According to Meredith (1998), case study frequently lacks generalizability, validation is inadequate, and the constructs are frequently flawed. These traits have multiple ramifications since countermeasures are required. A rigorous study design can reduce construct error, while a multiple-case design (Yin, 2018) or literature (Voss et al., 2002) can help boost generalizability.

After sufficient literature review, it was prominent that this study can form a good case research as it is in the exploratory stage and more of a descriptive nature. RQ1 explores the Axis' value chain and current ways to address sustainability in packaging. The interesting part of understanding after finding the answer to this question is how much focus is given to the sustainability aspect during decision-making related to packaging and what the hotspots in the current value chain need to be regulated with the proposed guidelines. For the RQ2, the purpose is to get the depth of knowledge related to regulatory frameworks in chosen markets and to create some conclusions in the form of guidelines for suppliers of the case company to manage the current packaging decision-making more sustainably.

Another applicable research methodology that suits this study is Action research. Change is the fundamental principle of action research: an issue is found and resolved, and then the solution is put into practice to help bring about the intended change (Reason & Bradbury, 2008). Though the two primary action research steps—implementation and evaluation—are crucial to this methodology, action research is not feasible within the 20-week timeframe of this thesis because change management projects take a lot of time and necessitate close collaboration over an extended period (Ibbs et al., 2001). In consideration of this, the utilization of the case study methodology is deemed the most suitable for this research and can successfully achieve its objectives.

2.2 Research Design

While designing the research questions and analytical framework for research, it was logical to go for a single case study but with more than one unit of analysis. This is because there are two units of analysis (UoA) that are connected and hence the design of this study was selected as an embedded case study. Yin (2018) presented a matrix for the design of various case studies. Depending on the case, its context, and the unit of analysis, it varies and one of the types is an embedded case study. This study is formulated in the same manner as shown in Figure 2.3 below.

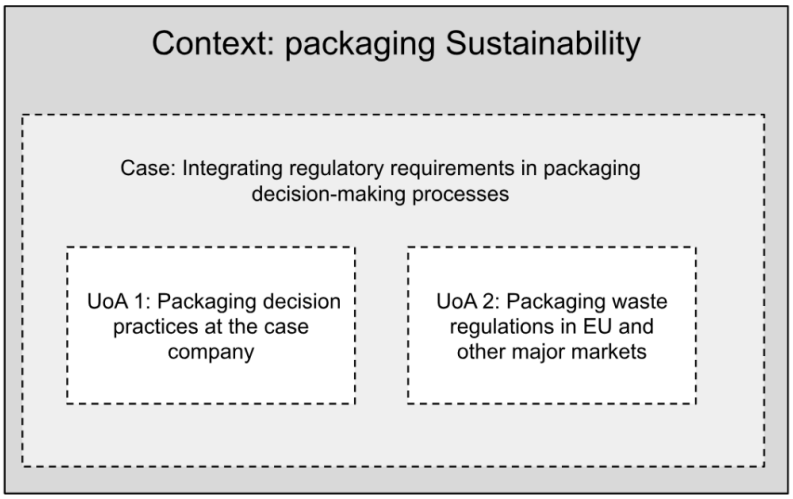

Figure 2.3: Embedded case study adapted from Yin (2018)

The UoA 1 will cover information regarding the current supply chain and packaging interactions, while also exploring the decision-making process regarding packaging in detail. The focus of the examination will be on the rise of sustainability issues in these areas and the strategies employed by the case company to address these challenges. The UoA 2 will explore the regulatory landscape concerning packaging waste in the EU and other significant markets, including the upcoming EU PPWR. The analysis will primarily investigate how these regulations are tackling packaging waste problems and how progress can be made by incorporating insights from the upcoming EU PPWR. These two assessments will offer insights into the status of packaging regulations both within the case company and on a legislative level in different countries. This will form the core of this case study by understanding how the case company can utilize this information to develop guidelines for suppliers and enhance packaging sustainability within the organization while being in the context of packaging sustainability.

Opting for a single case study allows for more in-depth observations, yet it lacks the potential to draw inferences that multiple case studies can offer (Voss et al., 2002). Hence, there must be a strong rationale to justify this decision. The following are the reasons to choose a single case study over multiple case studies: First off, there aren't sufficient resources or time for this study to conduct multiple case studies and reach the necessary depth. Second, a single instance can significantly contribute to knowledge and theory-building by confirming, questioning, or extending existing theories (Botting, 2021). The results of such a study can refocus future research in a field (Yin, 2018). Third, a single case company can provide the necessary resources and information more transparently than multiple case companies, considering the risk of migration of sensitive information. Supplier regulation is a strategic choice that, when done well, can provide a business with a competitive edge in sustainability aspects (Fiorino & Bhan, 2016). For this reason, this type of interaction will be thoroughly examined through a single case study analysis. Lastly, considering various B2B companies' strategies within the same market would add to the study's variables and complicate the understanding of packaging interaction in the supply chain. For instance, some businesses may have complete control over their supply chain and may have produced the majority of components themselves, while other businesses may have contracted out these services.

To not lose focus during the study and have a clear understanding of flow, the whole process is divided into three parts inspired by the case study procedure given by Yin (2018). Though the original proposition by Yin was given for multiple-case studies, it is still adapted for this single-case study as illustrated in Figure 2.4. The first chapter of the study, along with this chapter, forms the first phase of analytical

structure, i.e. define and design. Developing a research design flow facilitates careful selection of activities in research and helps to be focused. Among various activities, the guidelines framework will be fed back to the phenomenon of study, to check if it meets all the requirements set before, and if not, remaining things can be re-confirmed again. This loop will make sure no link will be missed in this study.

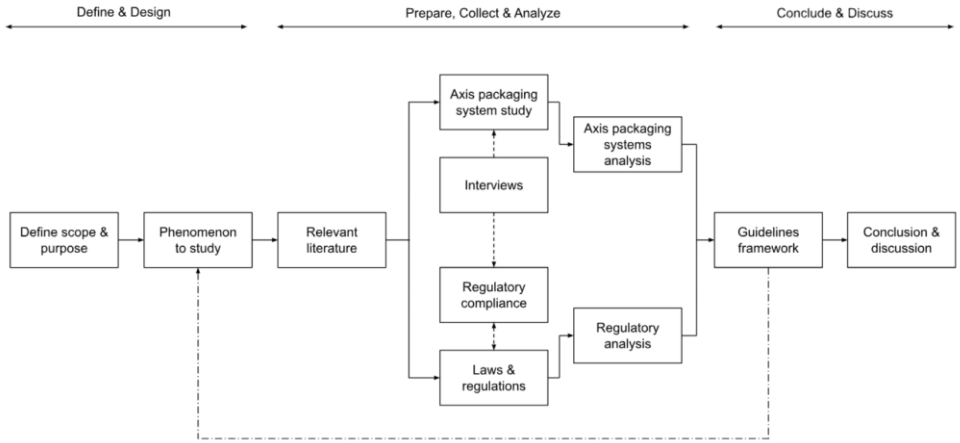

Figure 2.4: Case study procedure (adapted from Yin, 2018)

2.3 Research Framework

Having a research framework will aid in structuring this study more systematically in terms of designing, developing, and conducting the case research (Ebneyamini & Moghadam, 2018). To create a framework, a matrix form is used, taking research questions on one axis and three stages of the case study procedure on another. This matrix is then positioned with the UoA within them at the appropriate location which gives the structure as shown in Figure 2.5 below.

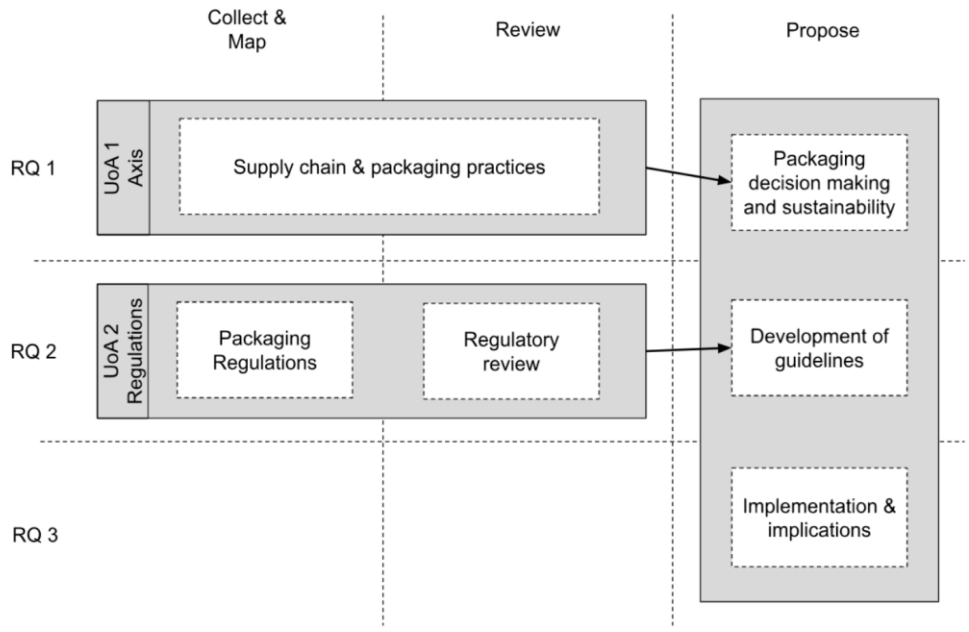

Figure 2.5: Research framework

This matrix makes it easy to visualize the scope of each unit of analysis at various steps as research progresses as it breaks down the units of analysis appropriately.

2.4 Literature review

For specific goals, the literature study was conducted in two stages. First and foremost, the initial review's objectives were to generate knowledge about pertinent subjects and subtopics, identify crucial keywords, and provide background information including interview guides and analytical frameworks. Second, to have higher-quality results and to close any knowledge gaps left by the first literature review, a second one is conducted.

The first literature review was carried out using *Scopus, Web of Science,* and *Google Scholar* to get the maximum relevant literature regarding the thesis. To do so, the main keywords were brainstormed and searched across these platforms. The following Table 2.1 will help to understand the keywords searched in various categories to search for relevant frameworks and concepts. After carrying out a detailed first literature review, it was observed that the North American region is still relatively new and exploring packaging waste management regulations. Hence

it was decided to study only states that have detailed regulations as relative to the EU.

Table 2.1: Search term sample for literature review

Category	*Keywords searched*
Packaging and Waste Management	Packaging Waste Packaging & Packaging Waste Directive (PPWD) Packaging & Packaging Waste Regulation (PPWR) Packaging Waste Management Municipal Solid Waste Management Sustainable Packaging Packaging Sustainability Packaging Regulations Packaging Laws Industrial Packaging Packaging Decisions
Environmental Targets and Responsibility	Extended Producers Responsibility (EPR) Science Based Targets Science-Based Targets initiative Scope 3 Scope 3 Science-Based Targets Sustainable Development Goals Producer Responsibility Organizations 9R Framework
Methodologies and Approaches	Case Research Case Study Systems approach Systems theory Guideline Development Supply Chain Mapping Supply Chain integration Packaging Interactions

The second literature review was conducted during the data analysis stage to connect the missing links in data wherever needed. Also, the forward referencing method was used whenever a good literature review was found. This helped to get the rich data quality required for this study.

2.5 Data collection

To gather high data quality, various data sources have been used in this study, including archival data, interviews, and observations. When performing case studies, it is common to incorporate various data sources, encompassing both qualitative and quantitative aspects (Guetterman & Fetters, 2018). It is good practice to include various data sources as they increase the credibility of the data presented, to have a triangulation of data (Smith, 2018).

2.5.1 Documentation

Because we live in a record-keeping society, every case study topic is likely to have documentary material, whether it be electronic or on paper (Yin, 2018). Documentation can be of various types, be it personal notes, administrative documents such as proposals, formal studies, or news articles. Yet documents are considered stable, unobtrusive, specific, and broad but at moments can be biased, difficult to access, or difficult to retrieve and the researcher's emotional engagement with documents may impact the data analysis (Barlow, 2016). Hence it is the responsibility of authors to carefully select the source for getting these documents and avoid biases. This study utilized various laws, regulations, and directives from various government sources. Such kind of documented material can be biased towards certain lobbies (Yackee & Yackee, 2006), hence while using them authors made sure to have rival explanations, such as from the Producer Responsibility Organizations (PRO) who are working in the same area of packaging waste management. To access similar content from the EU, the official website *EUR LEX* has been primarily used. Whenever the source is in a local language other than English, *Google Translate* is used. Also, documents from various organizations working towards the same objective, e.g., various PROs, are referred to strengthen the study.

2.5.2 Archival data

Archival data are data that are collected and preserved before the start of a research project to use them later (Das et al., 2017). This includes organizational archives as well as government database archives, each with its own set of advantages and disadvantages. The main advantage is the convenience of access to the data, which is either free or for a small fee. However, it is also crucial to consider the downsides

connected with this type of data, as it may have been obtained solely for documentation purposes and nonscientific reasons (Das et al., 2017).

In this study, archival data is used extensively to acquire information about various government-level statistics. Because the scope is highly particular to the packaging waste restrictions, there is minimal scientific material available, thus archive data can be extremely beneficial (Thomson & Berriman, 2021). In this study, the EU Statistics are accessed through *EUROSTAT*, the official website for all the EU statistics. Other countries' government websites are referenced too. The case company's data was gathered through the company's intranet whenever needed. The case company conducted a thesis by Strömberg & Tirougnanassambandamourty (2023) that examined packaging. Their data collection was also utilized in this study once its authenticity was confirmed by the relevant company people.

2.5.3 Interviews

This study used semi-structured interviews to collect data since case studies frequently require guided conversion rather than rigid queries (Rubin & Rubin, 2012). Many studies considered interviews to be a crucial form of data collection when utilized effectively (Voss et al., 2002). The primary reason for using semi-structured interviews is that the phenomenon being examined in this study is unconventional to the personnel at the case company, and thus obtaining natural ideas and thoughts on a topic is critical, which is challenging with structured interviews. Another reason to use semi-structured interviews is that they have a high response rate, and, because of their flexibility, responses are usually genuine and not biased.

Shorter case study interviews, lasting around 60 minutes, were used in this study because they are easy to prepare and fit the objective of data collection. An interview agenda is always supplied to the interviewee in advance of the session. Instead of sending questions, most interviewees were offered themes to be discussed in the interview as well as relevant context. Interviewees appeared at ease and the process kept interviews casual while staying within the parameters of the study. To solve this, before these interviews, relevant knowledge was obtained, which may facilitate discussion continuation during interviews.

In this sense, it is imperative to craft questions with extreme care so that interviewers come across as truly uninformed about the subject and enable the interviewee to offer novel insights into it (Leech, 2002). These kinds of interviews are favored when conducted with participants from the same case company since there is a

greater chance of a follow-up interview if needed. Because the possibilities of receiving a follow-up interview were limited and time-dependent, a brief questionnaire was sent ahead of time in the event of an external interview to make the most of the allotted time and avoid missing any important topics during the discussion. Table 2.2 gives ideas about the interviewees. Due to confidentiality clauses, the identity of the interviewee is not disclosed here. Whenever feasible, multiple informants from the same field of expertise were selected to reduce the biases in opinions.

Table 2.2: Interview Persons

Area	*Interview date*	*Duration*	*Interviewee role*	*Type*
Internal	2024-01-31	50 mins	Commodity Manager	On-site
	2024-01-31	50 mins	Purchaser	On-site
	2024-02-05	65 mins	Sr. Environmental Engineer	On-site
	2024-02-06	55 mins	Project manager	Virtual
	2024-02-08	60 mins	Packaging Engineers	On-site
	2024-02-09	60 mins	Industrial Lead	On-site
	2024-03-06	65 mins	Environmental Engineers	On-site
	2024-03-06	55 mins	Director - SC Sustainability and Environment	Lunch meeting
External	2024-04-15	60 mins	Managing Director - Producers Responsibility Organisation A	Virtual
	2024-04-21	55 mins	Managing Director - Producers Responsibility Organisation B	Virtual

No interview was recorded since the goal was to obtain more spontaneous responses from the interviewees without making them conscious (Nordstrom, 2015). Although recording provides you with a more accurate account of any interview than taking your notes, interviewees' listening skills may be impacted since they may believe that recording serves as a replacement for listening (Rutakumwa et al., 2020). In this study, to not miss any key information, one of the authors conducts the interviews, while the other writes down the responses. This reduces the likelihood of missing any important information. This does not restrict the note-taker from asking follow-up questions or the interviewer from taking individual notes. Following the interview, each of the authors individually wrote down their ideas, which were subsequently combined to create data. By doing this, it is easier to eliminate prejudice from interviewees' opinions.

2.6 Data analysis

Analyzing case study data is an underdeveloped component of doing case studies (Yin, 2018). Researchers often begin case studies without understanding how to navigate the gathered data (Lund, 2014). Case studies might become halted during the analytic step. To start, first, it is important to have a proper research analytical structure, such as the one presented in Figure 2.5 previously. "Playing" with the data is the first step in any analysis for finding trends, ideas, or concepts that have potential.

‘Improving decision-making in packaging can enhance packaging sustainability and, consequently, overall sustainability as well’, was the theoretical proposition on which analysis of UoA 1 relied, as this was how the study began in the first place. Koeijer et al., (2020) in their study also talk about the need for integrating sustainability considerations at the product design and decision-making stages. The propositions shaped the data-collecting plan, resulting in analytic priorities. This unit has less to explore and more to observe and hence as-is analysis has been used to capture the actual state of the organization concerning the packaging decision-making process. UoA 2 on the other hand has more to explore and play with the gathered data. To get the best out of regulatory frameworks, pattern matching, and tabulation forms of analysis are largely used. This helped to visualize data in better ways. Finally, these two units were merged to answer the case proposition of creating packaging guidelines. Explanation building suits this purpose very well.

2.7 Research quality

Yin (2018) proposes employing four criteria for evaluating the quality of the research design: construct validity, internal validity, external validity, and reliability. These criteria aid in evaluating the quality of the research design as it should reflect a coherent set of statements.

2.7.1 Construct validity

Construct validity involves using appropriate methodologies for the concepts being examined (Yin, 2018). Case studies are susceptible to researcher bias during data collection (Flyvbjerg, 2006). To address this criticism and ensure fair data collection, multiple sources of evidence were utilized. The validation of UoA 1 was achieved with the assistance of supervisors from the case company during weekly review sessions. This process was particularly useful when transcribing information from multiple interviewees about the supply chain and packaging decision-making processes at the case company, helping to identify and correct any errors or misunderstandings.

2.7.2 Internal validity

This study is neither explanatory nor involves numerous inferences, so internal validity is not a significant threat in this context and can aid in better data analysis (Yin, 2018). Internal validity will be relevant in the data analytics phase, particularly in pattern matching across various country regulations and rivalry explanations. To develop a robust rival explanation regarding regulations, especially the upcoming PPWR, interviews were conducted with two PROs who are actively working on Packaging and Packaging Waste Regulation (PPWR) and advocating for changes in some articles. Understanding the factors that could affect the successful enforcement of these regulations and their consequences on the industry was essential.

2.7.3 External validity

External validity is concerned with the generalizability of research findings beyond the original study context (Yin, 2018). One challenge of single-case studies is their difficulty in generalizing results. Nevertheless, single-case studies aim to offer in-

depth knowledge rather than broad generalizations (Retolaza & San-Jose, 2017). This study, utilizing archival data, has the potential to expand its findings across various periods and geographical areas (Delios et al., 2022). Even though the research centers on a specific case company, the broader significance of the subject implies its applicability on a wider scale, enhancing the representativeness of the study.

Many companies lack internal development capabilities and could benefit from enhancing packaging through supplier regulations (Sohrabpou et al., 2016). The propositions presented in this study could prove highly advantageous for such companies, emphasizing the possibility of generalization. The authors have included comprehensive contextual details about the case company and the phenomenon being studied, strengthening the rationale for the research. Moreover, the ability to transfer and replicate the study's outcomes in similar contexts further reinforces the external validity of this research.

2.7.4 Reliability

Reliability indicates whether the same techniques will yield the same outcomes when applied repeatedly (Yin, 2018). To achieve reliability during the design and data collection phases, two strategies were implemented. First, the research followed a formalized and standardized case study process, which included an interview guide and an analytical framework explicitly developed from theory and in a generic way suitable for case research (Baxter & Jack, 2008). Second, an organized and comprehensive case study database was created, containing transcriptions of interviews, archived data, and other materials. During the data analysis process, effort was made to clearly explain and provide examples of the frameworks and reasoning that led to the results.

3. Frame of Reference

This chapter starts the 2nd phase of analytical structure and presents a rigorous literature study that has been conducted to achieve the purpose of this master's thesis. It covers the central theoretical findings related to the research area and the research objectives. The frame of reference introduces terminologies, concepts, and frameworks that will be applied to execute the empirical study and analysis. The broad classification of literature can be visualized in the following Figure 3.1

UoA 1	UoA 2
Systems Theory Industrial Packaging Supply Chain & Packaging Mapping Supply Chain Integration	Packaging Sustainability Managing Packaging Waste EU PPWD EPR Science Based targets

Figure 3.1: Frame of reference categorization

3.1 Theoretical Foundations

3.1.1 Systems theory

A system is a group of individual parts that work together to form a unified whole (Pålsson, 2018). System theory allows one to examine a phenomenon as a complete unit instead of individual units. It would allow one to understand how all parts influence each other within the bigger system. It facilitates problem-solving, by viewing problems and challenges as parts of an overall system, rather than reacting to specific parts or outcomes, and helps avoid sub-optimization by focusing on the primary purpose of a system (Pålsson, 2018; McGlacken-Byrne et al., 2023). By

examining a system as a whole, it is easier to understand how each part contributes to the overall purpose.

The system perspective in packaging logistics emphasizes that the focus is on the performance of the packaging system (García-Arca et al., 2022). It is important that each of the primary, secondary, and tertiary packaging performs satisfactorily, but also to remember how they interact. It is therefore necessary to zoom in and out to evaluate the three levels of packaging as a system. The trade-offs can be pointed out and are represented in the interaction between the packaging system and the logistics process. As a result, rather than thinking of the system as made up of separate things, it is necessary to concentrate on its interactions (Hellström & Saghir, 2007). Changes or modifications of the packaging system can influence other systems; therefore it becomes important to map the relationships between the various systems.

A systems approach in packaging logistics gives an overall picture of the many roles of packaging. This helps to analyze and balance packaging requirements. Trade-offs and interactions can be found within the packaging systems (primary, secondary, tertiary), between functional areas (logistics, marketing, environment, etc.), and between the supply chain actors.

When applying a systems approach to investigate how the individual parts in a system influence each other, one can use the zoom-in and zoom-out techniques (Azar, 2012) repeatedly. Zooming in means that one part of the system is enlarged to provide a detailed view of that part while zooming out shows each part's links to the overall influence on the system (Imaz, 2011). By continuously shifting between zooming in and out, the effect of a modification to one part on the whole system can be identified, thus avoiding sub-optimization.

3.1.2 Supply Chain and Packaging Mapping

Visualizing, tracking, and managing supply chains all become more complicated as firms pursue outsourcing strategies, and as firms' supply and delivery systems become increasingly global (Gardner & Cooper, 2011). It is necessary to map the different actors and activities in the supply chain to develop the initial knowledge. To address the impact of supply chain configuration on supply chain planning, management, and control activities, mapping offers the necessary degree of understanding (MacCarthy et al., 2022). In every supply chain, the actors are unique and different from one another. The different combination of actors shapes the

dynamics, efficiency, and resilience of the supply chain, making it essential to map out the connections for effective decision-making and optimization.

Mapping serves as a bridge between corporate strategy and supply chain strategy. By cataloging and distributing key information, mapping provides a clearer picture of the supply chain's structure and dynamics (Castellano & Gobbo, 2018). It illuminates the distribution of power among the various actors involved, allowing for more informed decision-making, and improving collaboration (Gardner & Cooper, 2011). A good map highlights potential constraints within the system and could pinpoint areas for redesign or modifications. Finally, mapping makes it easier to monitor the supply chain integration process and ensure it remains responsive.

The supply chain for the packed products is to be mapped along with all processes and activities to understand packaging requirements (Mikkelsen et al., 2022; Pålsson & Sandberg, 2020). The packed product is often involved in more than one supply chain and many times in a network of supply chains with many variations (Molina-Besch & Pålsson, 2014; Inns, 2012). A product can be manufactured in one or more plants and then sent to one or several warehouses. It is possible to employ a top-down mapping strategy, in which additional details are added after the general system has been defined. This top-level mapping is then followed by detailed mapping of one dedicated supply chain with one actor per stage.

Understanding the nature of the interaction between packaging and other organizational systems is essential to gaining insights into the supply chain's packaging system. García-Arca et al. (2006) refer to the importance of considering the different functions to which packaging is subjected, from the initial stages of development of a new product. Furthermore, indicating that it is essential for this process to incorporate the view of all the members in the supply chain. The detailed mapping of logistics, procurement, and environmental activities related to packaging gives an overview of the physical environment for the packaging system in the supply chain. Before making packaging decisions from a supply chain viewpoint, it is necessary to comprehend the packaging environment (Hellström & Saghir, 2007; García-Arca et al., 2022). Interaction mapping can also be used as a platform to analyze and discuss tangible packaging-related issues. It shows what packaging aspects are important in various processes along the supply chain (Hellström & Saghir, 2007). Ultimately, it serves as an aid in identifying packaging-related improvements and for encouraging a packaging focus on sustainability.

3.1.3 Supply Chain Integration

Supply chain integration is a key concept for packaging. It describes how various supply chain parts are coordinated and integrated into a cohesive whole. The level of integration depends on the extent to which separate parties work together cooperatively to arrive at mutually acceptable outcomes. Inns (2012) and Khanuja & Jain (2019) assert that supply chain integration aims to optimize flows rather than activities, thus balancing costs and services throughout the chain.

The flow in the supply chain can be either physical or information (Pålsson, 2018). Packaging plays a vital role in both. In the physical flow, packaging influences logistics from the point of filling until the point of consumption. This includes the necessary synchronization of requirements on packaging functions. In the information flow, packaging is an information carrier throughout the supply chain. Packaging systems should be designed or selected to facilitate the integration of both physical and information flows.

Integration in a supply chain can take different forms. Vertical integration refers to coordination and collaboration between the different actors within the supply chain. For example, this would include the relationships and interactions between suppliers, manufacturers, and distributors. Horizontal integration occurs between entities at the same level of the supply chain but at different nodes. This could mean that two outsourcing manufacturers collaborate to share information and resources. Internal integration refers to integration between functions within a company, whereas external refers to integration between companies.

3.2 Packaging and Sustainability

3.2.1 Industrial Packaging

Industrial packaging affects many processes, such as purchasing, logistics, production, transportation, warehousing, and recycling. Industrial packaging is often used in larger quantities than primary packaging, and the scale of its use may require different management to ensure that its environmental impact is properly managed (Bouhlel et al., 2023). A more competitive and effective supply chain can be achieved with well-informed industrial packaging selection principles, where several trade-offs have been considered and the implications of packaging selections are known (Matyi & Tamás, 2023). For instance, a separate design model for

industrial packaging may be required to optimize the use of materials, reduce waste, and ensure efficient transportation of goods. In recent times, it has become increasingly challenging to make well-informed choices of industrial packaging because the complexity of supply chains has increased, and supply chains have become increasingly global.

A packaging supplier produces packaging and delivers it to a component supplier. Packaging selection principles should guide how to minimize and manage trade-offs between strategic and operational packaging development (Koeijer et al., 2017). The principles of packaging selection should include not just the direct and indirect impacts of packing. Some selection guidelines for industrial packaging are (Pålsson, 2018):

- Sourcing and production strategy decision principles
- One-way or reusable packaging decision principles
- Packaging size decision principles
- Scale affects decision principles
- Volume and weight utilization decision principles

3.2.2 Packaging Sustainability

Packed products have direct and indirect effects on the environment. The direct effect arises from the packaging material, in terms of its environmental impact during production and in packaging waste. The indirect effects are related to packaging impacts on logistics and transport efficiency, and the capabilities of packaging to prevent product waste (Pålsson, 2018). In recent years, public authorities and public discussions have focused on minimizing packaging waste and the use of resources. In response, legislation on global procedure responsibility to minimize packaging waste and promote recycling has been enacted (Ibrahim et al., 2022). Thus, it has become logical that companies tend to focus on packaging material minimization and recyclability when they aim for environmentally efficient packaging.

Packaging material is a way of managing the environmental impacts of packaging (Pålsson, 2018). For sustainable development purposes, it is essential to minimize waste, both from the packaging material and the products. In supply chains, particularly in global ones, the packed products are exposed to many challenges that can damage the packaging and result in product waste. The packaging material may be damaged or exchanged by different actors before the product reaches its destination. Unless each part of the supply chain is linked to an appropriate waste

handling system, the packaging waste can end up in landfills. Companies have limited insights into the whole supply chain, which results in a lack of transparency. This means that it is difficult to make an environmentally efficient packaging selection for the whole supply chain or to control where packaging waste ends up.

A certain amount of packaging material is necessary to protect the product. When selecting packaging, the thickness of the material and the packaging dimensions should be considered (Pålsson, 2018). An underpacked product is not sufficiently protected, which leads to product waste. Contrarily, an overpacked product results in packaging waste. A balance is required to ensure protection and reduce the amount of waste generated.

The packaging material should be made of as few different materials as possible, as mixed materials complicate the recycling process (Seier et al., 2023). Usage of mixed materials should be minimized (Pålsson, 2018). Packaging material should be free of any hazardous substances. It is also important not to emit toxic substances from used packaging into ecosystems in the recycling or waste handling processes. If hazardous substances cannot be avoided, their presence should be communicated through standardized statements and pictograms on labels along with safety data sheets on the package. Transport efficiency and logistics are also impacted by packaging (Ahmad et al., 2022). The total cubic usage of the primary, secondary, and tertiary packing is referred to as the volume efficiency of packaging systems. It describes how much air, or empty space, is transported, handled, and stored.

Circular economy (CE) is a concept being promoted by the EU, and by several other national governments including Japan, Canada, and several businesses around the world. It is recommended as an approach to economic growth that is in line with sustainable development (Korhonen et al., 2017). CE can be defined as an economic model aimed at the efficient use of resources through waste minimization, reduction of primary resources, and closed loop of products, product parts, and materials within the boundaries of environmental benefits (Morseletto, 2020). The concept of CE emerged as a potential solution to the overconsumption of natural resources by humans while at the same time piling up waste. Thus, CE strives to minimize resource exploitation and maximize waste prevention.

Potting et al. (2017) suggest that several circularity strategies exist to reduce the consumption of resources and minimize the production of waste. They have developed a model which defines 10 strategies for circularity. All the R-lists shown in Figure 3.2 resemble each other and differ mainly in the number of circularity strategies they put forward. They present a range of strategies ordered from high circularity (low R-number) to low circularity (high R-number).

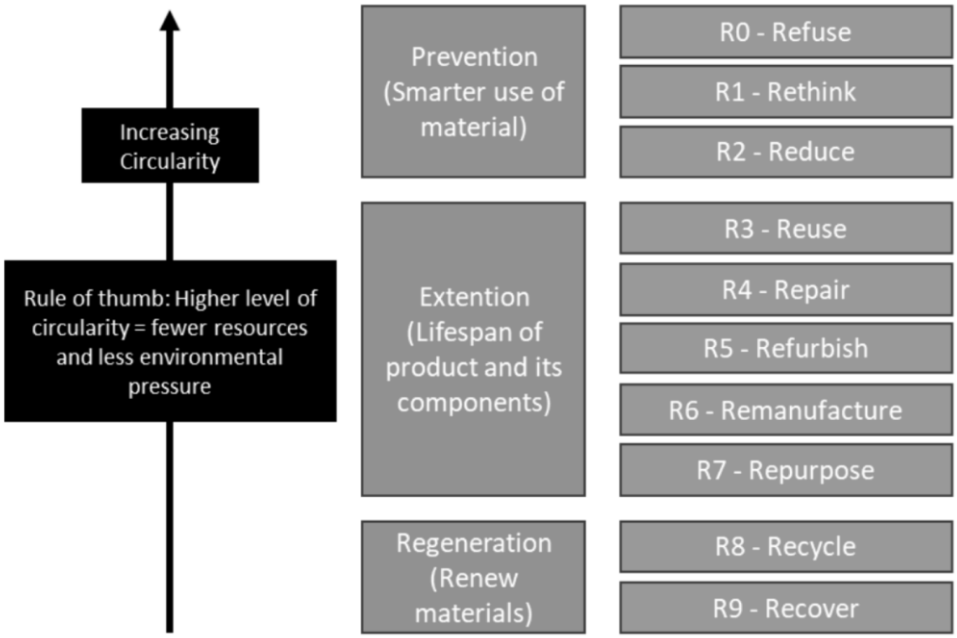

Figure 3.2: Circularity strategies (Adapted from Potting et al., 2017)

However, authors like Velenturf & Purnell (2021) argue that though CE has potential benefits, some concerns have been raised regarding circular practices being promoted as sustainable yet resulting in detrimental impacts on the environment and society. Determining which practices and systemic changes are indeed sustainable and circular requires rapid assessment tools with a whole system perspective.

3.2.3 Managing Packaging Waste

The waste management practices depend on packaging characteristics that are material-specific, industry-specific, and country-specific. The waste from packaging systems is related to primary, secondary, and tertiary packaging. Each level of the packaging system can be exchanged several times in a supply chain. There are typically two types of waste generated, either industrial waste or household waste (Pålsson, 2018). One main difference between the two is that it is easier to predict and plan the collection of packaging waste from an industrial setting than from households.

Packaging waste occurs throughout the supply chain. Thus, each actor needs a waste collection system. It should be stressed that packaging waste needs to be collected and transported from each actor in the supply chain as shown in Figure 3.3. This

system can become very complex due to several suppliers, manufacturers, and warehouses.

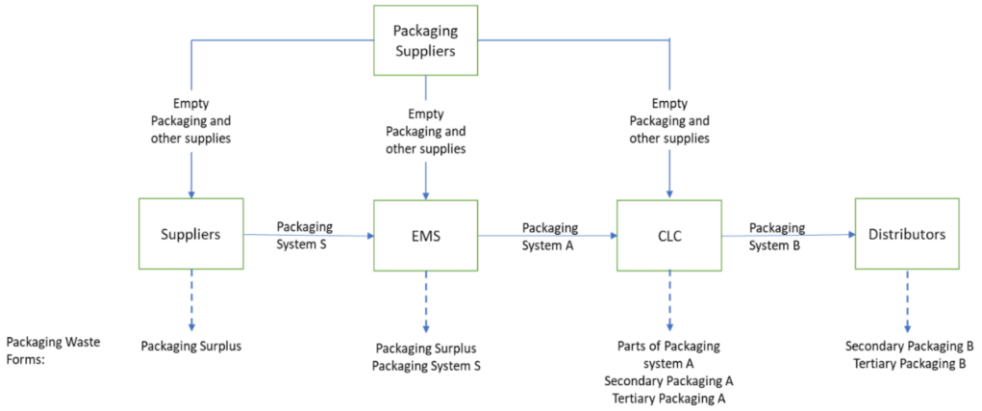

Figure 3.3: Packaging waste throughout the supply chain (Adapted from Pålsson, 2018)

3.3 Regulatory and Strategic Frameworks

3.3.1 Extended Producer Responsibility

Organization for Economic Co-operation and Development (OECD, 2001) defines EPR as 'an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle including its final disposal'. This approach shifts the financial or physical responsibility of recycling upstream to the producers and calls for incentivizing the producers to incorporate environmental considerations in product design (OECD, 2001). Both the producers and the consumers are the waste generators. In the 1990s, Germany was among the pioneering nations to establish an EPR system for packaging, and it has undergone substantial advancements since then. Later in 1994, the European Union (EU) brought its Packaging and Packaging Waste Directive (PPWD), which sets some guidelines for its member states to effectively manage their packaging waste and set some recycling targets for the future.

EPR encompasses both the upstream and downstream stages of the product life cycle. It is one of the major waste management policy instruments that support the implementation of waste hierarchy (Filho et al., 2019). It is recognized that EPR can significantly help to contribute to achieving existing waste targets, and the more

ambitious targets in the Circular Economy. EPR for packaging has contributed to significant increases in recycling rates in the EU. This applies also to plastic packaging where recycling reached an average of 40% in 2015, which is well above the requested 22.5% of the EU Packaging and Packaging Waste Directive (Watkins et al., 2017).

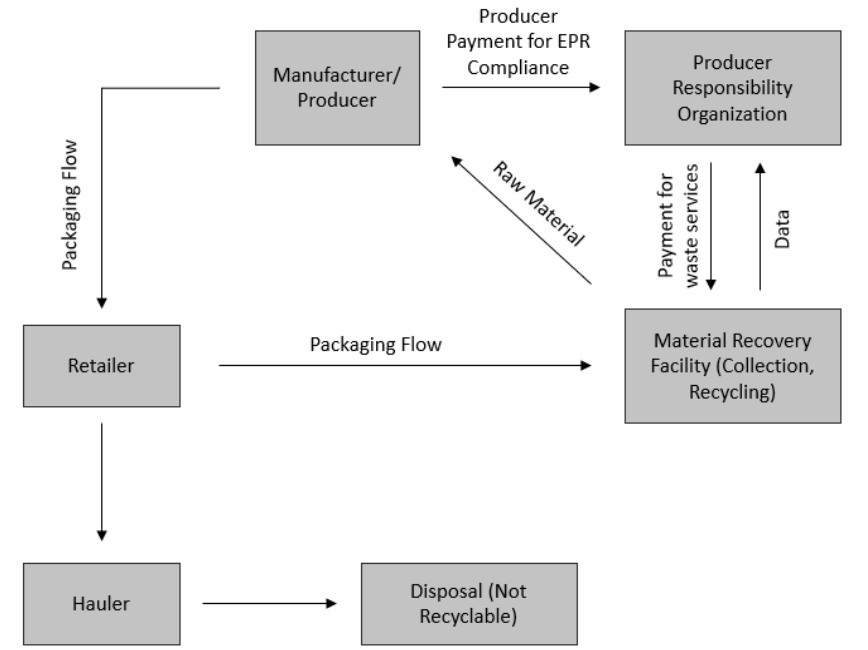

Figure 3.4: Role of PROs (Adapted from Mayers, 2008; Tumu et al., 2023)

Producers commonly join together and form national collective compliance schemes or producer responsibility organizations (PROs) to ensure compliance with EPR requirements (Mayers, 2008). The role of PROs has become pivotal in the implementation of EPR; they provide an important interface for organizing financial transactions, collections, and communications among governments, producers, waste companies, retailers, and municipal authorities. The functioning and working of PROs are depicted in Figure 3.4. Several member states have adopted their own national or regional legislation that introduces the collection and recycling of waste streams.

3.3.2 Packaging and Packaging Waste Directive

In 1992 the European Commission introduced a directive on packaging and packaging waste. The central aim of this directive was to minimize and prevent packaging waste wherever appropriate and to reuse, recycle, or recover packaging waste so that less goes for final disposal (European Commission, 1994). "Packaging" includes not only primary packaging but also secondary and tertiary packaging materials which may assist in warehouse handling and distribution. The foremost goal of the EU is to prevent packaging in the first place. Where packaging cannot be avoided, it should be reused, and recycled or its energy should be recovered. A timeline of the EU PPWD introduction is shown in Figure 3.5.

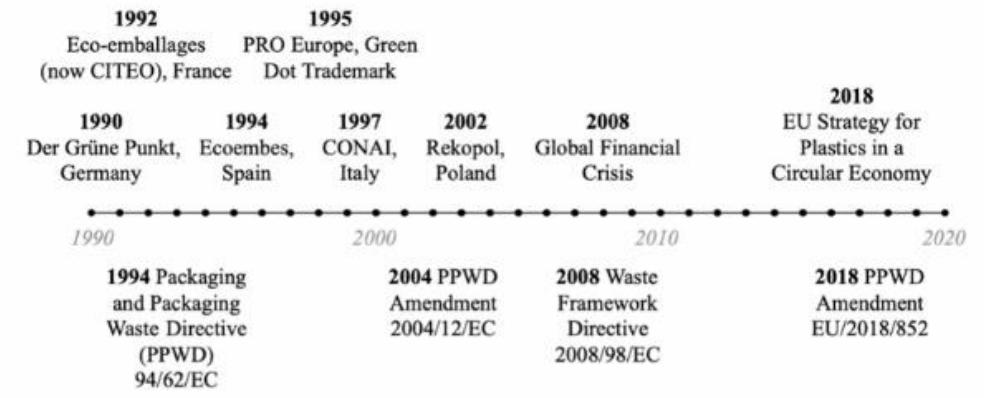

Figure 3.5: PPWD Timeline

In 2021, the Commission indicated that it would propose, as part of the European Green Deal and the new Circular Economy Action Plan, a revision of Directive 94/62/EC on Packaging and Packaging Waste (Legislative Train Schedule, 2024). The initiative would bolster the requirements for packaging to ensure their reuse and recycling, increase the amount of recycled content, and improve their enforceability. It would also include measures to tackle over-packaging and to reduce packaging waste.

The proposed regulation would apply to all packaging and all packaging waste. It would set out requirements for substances in packaging. Furthermore, all packaging would have to be recyclable (designed for recycling and recycled at scale). The proposal would also introduce minimum recycled content in plastic packaging, with some exemptions. The percentages would increase from 2040. Table 3.1 shows a set of specific recycling targets for recycling set in the directive.

Table 3.1: Recycling Targets (European Commission, 1994)

Type of Packaging	*Current Targets (%)*	*By 2025 (%)*	*By 2030 (%)*
All Packaging	55	65	70
Plastics	25	50	55
Paper and Cardboard	60	75	85
Glass	60	70	75
Wood	15	25	30

The key measures to bring about change on the ground include (European Commission, 1994):

- targets for packaging waste reduction at the Member State level, and mandatory reuse targets for economic operators for selected packaging groups
- restricting over-packaging and certain forms of unnecessary packaging, and supporting reuse and refill systems
- establishing criteria for design for recycling to be applied to all packaging
- minimum inclusion rates for recycled content in plastic packaging
- mandatory deposit return systems for plastic bottles and aluminum cans
- harmonized labeling of packaging and waste bins to facilitate correct consumer disposal of packaging waste

3.3.3 Science-Based Targets

Science-based targets (SBTs) are a way for companies to define emission reduction targets. Science Based Targets Initiative (SBTi) is a collaborative effort between the United Nations Global Compact, the Worldwide Fund for Nature, the World Resources Institute, and the Carbon Disclosure Project (SBTi, n.d.). SBTs are specific, measurable objectives set by companies to align their GHG emissions reduction efforts with the Paris Agreement's goals. The targets take into account the company's sector, geography, and business model to create a customized strategy for emission reduction (SBTi, n.d.). The SBTi's goal is to enable companies

worldwide to do what climate science requires of the global economy: to halve emissions by 2030 and achieve net zero before 2050.

Supply chain emissions are on average 11.4 times higher than operational emissions, more than double previous estimates, due to suppliers improving their emissions accounting (Carbon Disclosure Project, n.d.). Setting targets to reduce emissions throughout the value chain (Scope 3) is becoming a new business norm. This is only achievable with strong supply chain engagement. More buyers are demanding disclosure and more suppliers than ever are responding. Moving forward, suppliers should prepare for more businesses engaging them in environmental disclosure and action and begin to pinpoint and address the risks in their value chains.

However, suppliers are still not acting down the supply chain. Only 37% of suppliers are engaging their suppliers to reduce emissions (Carbon Disclosure Project, n.d.). More buyers need to encourage good leadership practices among their suppliers, with suppliers in turn engaging with their value chains. A collectiveness of supply chain action is the key to building a resilient, thriving economy.

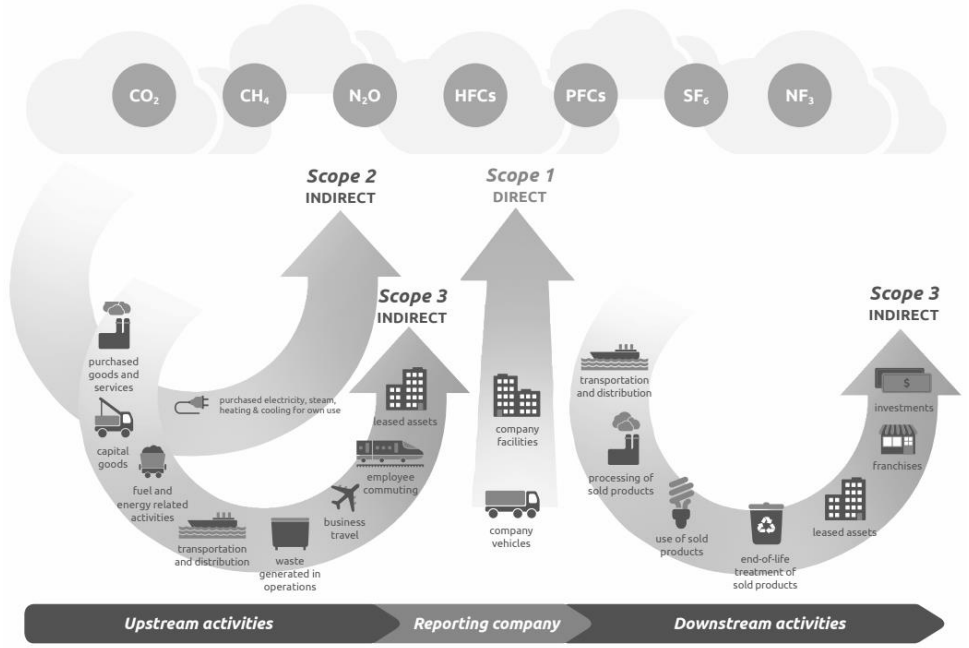

Figure 3.6: Understanding Scope 1,2,3 (SBTi, n.d.)

Scope 3 targets are a requirement under the SBTi Net-Zero Standard (Science Based Targets, 2023). Scope 3 emissions are defined as indirect GHG emissions that occur

in a company's value chain. The activities under Scope 3 are shown in Figure 3.6. It generally includes emissions from procured goods and services, transportation and distribution, operational waste, and the use of sold products. These emissions can constitute most of the company's total GHG emissions. Analysis of Scope 3 emissions is difficult given the absence or insufficiency of data (Gomes et al., 2023; Hettler & Graf-Vlachy, 2023). Therefore, it becomes difficult to measure Scope 3 because firms are unable to control their suppliers' emissions. Hence, firms must assess their suppliers' strategies and integrate more sustainability criteria. Reporting of Scope 3 disclosure is not mandatory and depends on the country where the company operates and the type of company (eg. size and revenue) (Aligned Incentives, 2023; Hettler & Graf-Vlachy, 2023).

4. Case Study Description

This chapter presents the case company data and evaluates the related sustainability concerns in the packaging decision-making process. It aims to identify where these concerns arise and how they are currently being addressed. At present, there is no formal decision-making process map for packaging, so the authors have mapped the various interactions between supply chain actors to locate the areas of concern. These processes are then reviewed to understand the need for guidelines based on regulations to improve the packaging decision-making process. The following Figure 4.1 illustrates which part of the framework will be addressed in this chapter.

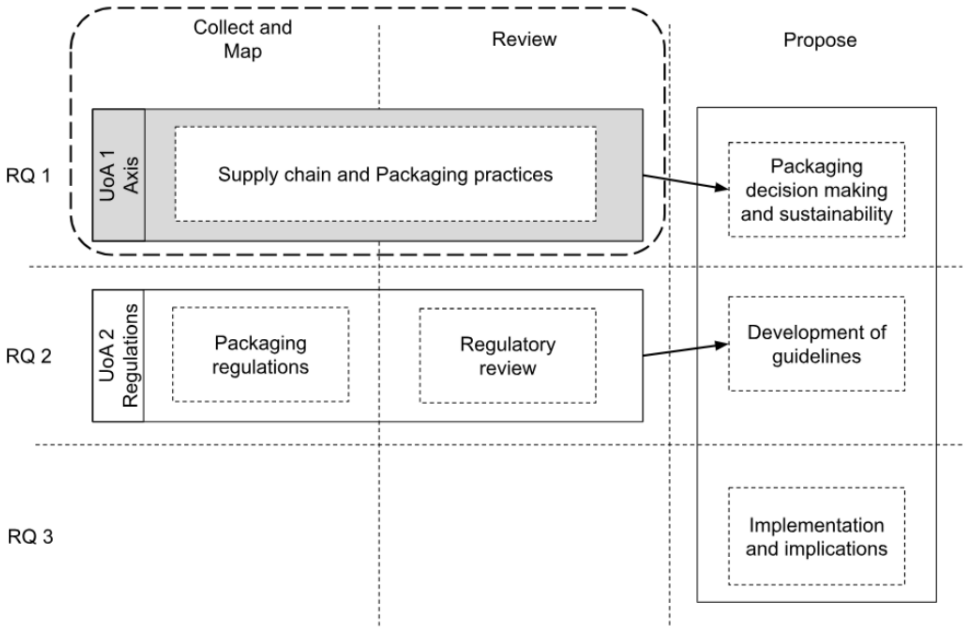

Figure 4.1: Research framework

4.1 Context and Background

Axis Communications is a market leader in network technology and provides solutions for audio systems, video surveillance, access control, and intercoms. The company's main strength is its strong focus on innovation. While Axis does not own any production facilities for its products, it succeeds in the market with its supply chain partnerships. Axis is currently focusing on a more sustainable supply chain. It is visible through its vision, mission, and future plans. Still, in reality, it is a stricter path to have a sustainable supply chain as it contains many obstacles such as financial constraints, lack of awareness of the benefits of sustainability, lack of green purchasing, and lack of regulations & enforcement of environmental standards among many others (Menon & Ravi, 2021). Axis has ambitions to go circular but at the moment it is still much linear, as implied by various participants during the interview. Axis higher management has set high ambitious goals on reducing 'Scope 3' emissions within its supply chain upstream activities, i.e. to reduce these emissions by 51.4% by 2030, compared to the year 2022. To achieve this target, companies need to consider their packaging activities as well from early in the supply chain (Afif et al., 2024). Bjørn et al., (2022) in their review of emerging evidence also noticed that the scope 3 emissions can generally be higher than the other two and hence critical to control them.

4.2 Supply Chain and Packaging Practices

To understand the packaging practices at Axis, it is important to understand the supply chain and decision-making at Axis. This will help to understand how this affects the operations. Understanding the supply chain will help to know the interactions among all the actors involved and how various packaging systems interact with these actors. Decision-making practices will lead to understanding what sustainability concerns are considered during the initial stages and how they are addressed.

4.2.1 Supply Chain and Integration

Axis, being an innovation-focused company, primarily emphasizes new product development, innovation, and ongoing enhancements (Arvanitis & Loukis, 2013). At the strategic level, the company's choice was to outsource manufacturing and warehousing operations, focusing resources on development efforts. Axis responsibly sources components and parts from its diverse supplier base. These suppliers are the first main link in the supply chain and provide all the required components and parts to the production facilities. The electronic products are produced by contract manufacturers referred to as 'Electronic Manufacturing Services' (EMS), and then dispatched to 'Configuration and Logistics Centers' (CLC). At CLCs, the items are configured and packed into sales units based on received orders, also functioning as warehouses to store inventory. Axis, in the sales aspect, does not directly offer products to end consumers; instead, it engages in B2B channels, collaborating with distributors and integrators for product marketing and sales. Within this well-thought supply chain framework, Axis plays a crucial role as a proficient coordinator, ensuring a harmonious balance among the various entities in a multi-tiered supply chain, as depicted in Figure 4.2.

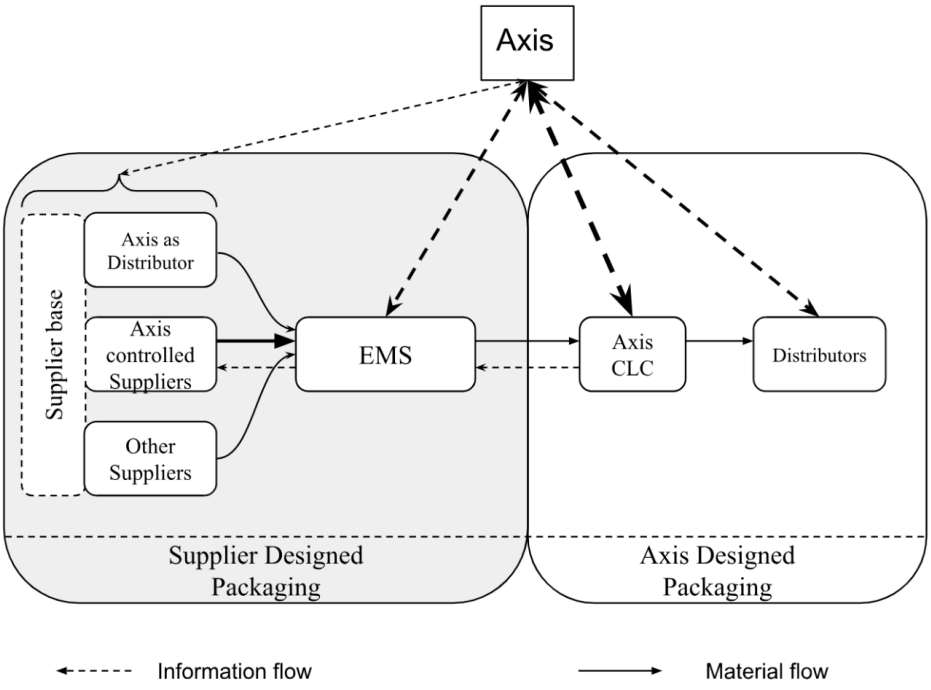

Figure 4.2: Packaging at Axis

Even though Axis does not own any facility, Axis has great control over actors in the supply chain through strong data and information sharing. This can be visualized in the above figure where the thickness of the arrows illustrates the degree of information sharing and control. This strategy allows Axis to focus on its core competencies while leveraging the expertise and resources of external partners to optimize efficiency and reduce costs (Arvanitis & Loukis, 2013).

As products progress through the supply chain, the packaging is also updated at each stage. To facilitate research, the packaging in this supply chain is categorized into groups based on who owns the packaging development. This results in two categories: 'Supplier Designed Packaging' and 'Axis Designed Packaging' as illustrated in Figure 4.2. Axis possesses an internal team specialized in packaging engineering that works on enhancing sales unit packaging further down the supply chain. Conversely, the packaging upstream in the supply chain is created by suppliers and then endorsed by the Axis sourcing quality team. Since Axis has dedicated resources for packaging in the second category, this study will focus solely on packaging and decision-making processes in the first category. Zooming into this category will provide the in-depth context of packaging decision-making processes currently in place and pinpoint areas of concern.

Implementing such a strategy requires different kinds of supply chain integrations as seen. Figure 4.3 illustrates various integrations at the case company.

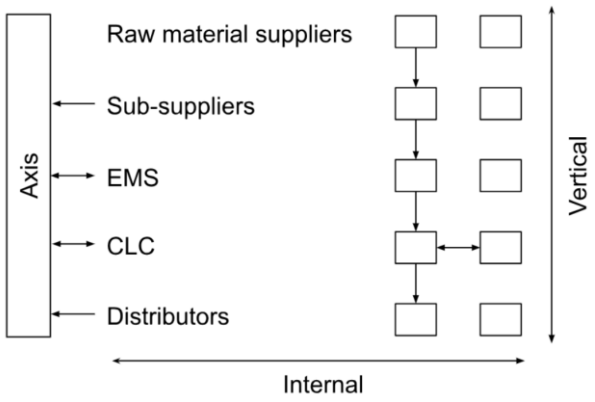

Figure 4.3: Supply chain integration at Axis (inspired by Pålsson (2018))

Axis, as a central entity in the supply chain, controls the flow of goods, information, and resources. This control enables Axis to dictate how products move through the supply chain and how information is shared among various actors. Other actors within the chain are internally integrated in the manner shown, predominantly vertical-forward integration among the actors.

4.2.2 Packaging Systems and Waste Management

At the operational level, packaging at Axis changes its form at nearly every point in the supply chain. This is largely due to the specific operations conducted at each node. Axis products consist of various parts and components, and there are generally hundreds of suppliers involved in the process. At each level, transitions occur, such as from components to sub-assemblies or assemblies to finished products. These transitions result in different packaging systems at each node within the supply chain. The following Figure 4.4 illustrates the changes in packaging systems at various nodes.

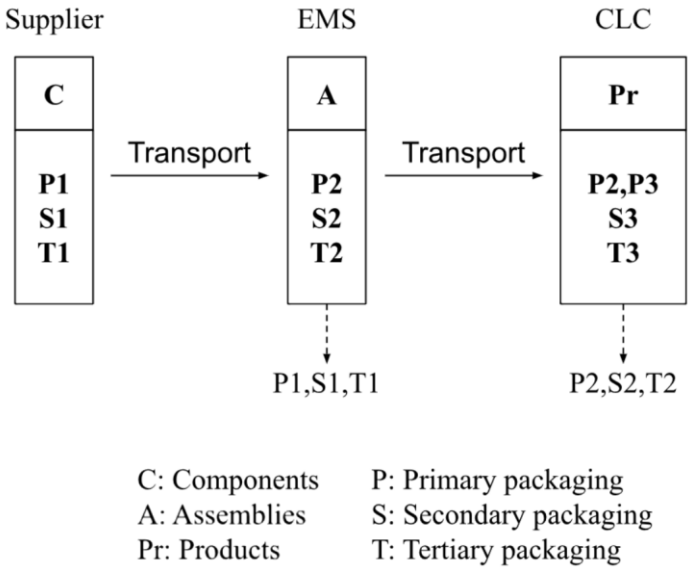

Figure 4.4: Packaging systems at Axis (Inspired by Pålsson, 2018)

Currently, there is no reuse of any packaging material except pallets. No packaging is in a loop with the previous actor, and hence most of the packaging is becoming waste at the next node. Considering the high number of suppliers, this waste generation is very high at EMS compared to other actors involved. This waste consists of various plastics including bubble wraps, expanded polystyrene, plastic trays, paperboard, and pallets, both plastic and wooden (Strömberg & Tirougnanassambandamourty, 2023). These packaging materials are of various types as shown in Figure 4.5, and once they become packaging waste, it is crucial to handle them.

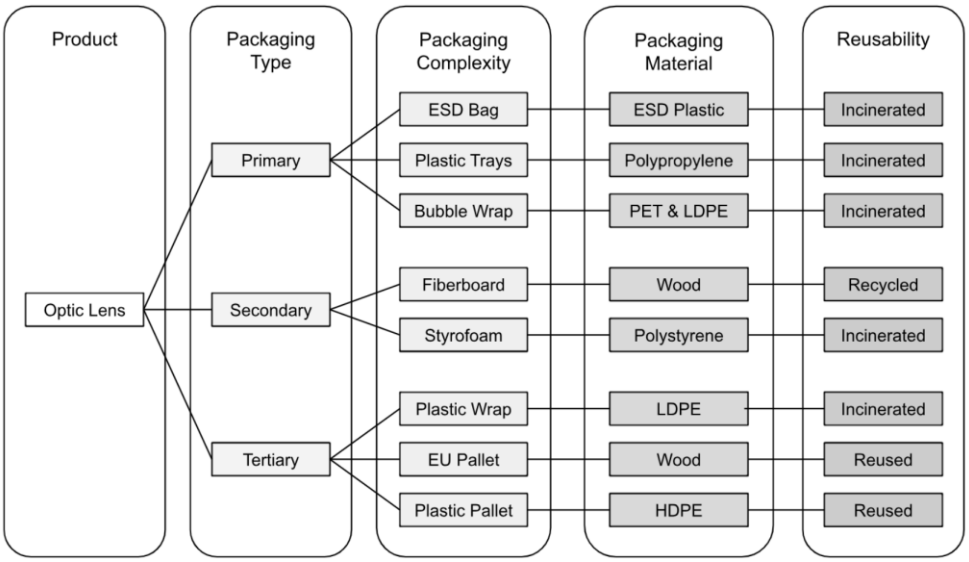

Figure 4.5: Packaging taxonomy at Axis for a product (Data from Strömberg & Tirougnanassambandamourty, 2023)

Especially at the EMS locations, this issue is prominent, considering various components are coming from various suppliers. To help it understand in better terms, Figure 4.6 presents the process map, illustrating the flow and form change of any component in the value chain as it proceeds. As illustrated, suppliers pack their components in various forms of packaging. While not all levels of packaging are always necessary, the diverse types of components mean that all levels can be observed. When these components reach the EMS from various suppliers, a quality test ensures that all set requirements are met. If there is critical damage to the product shipment, it is rejected, and EMS escalates the issue to the Axis sourcing team. However, if there is minor damage to the packaging but no damage to the product, there is no escalation. These requirements are currently more product-centric, with minimal focus on packaging, except for ensuring there is no visible damage to the packaging or the product inside.

Once approved, the packaging is discarded, and the products are moved to the incoming warehouse and stored in an ESD-safe (Electrostatic Discharge) environment. When these components are used in assembly, they are repacked with primary packaging in a clean room environment and shifted to an outbound warehouse for further packaging. Subsequently, they are transferred to the CLC (Central Logistics Center) for final configuration and assembly into sales units.

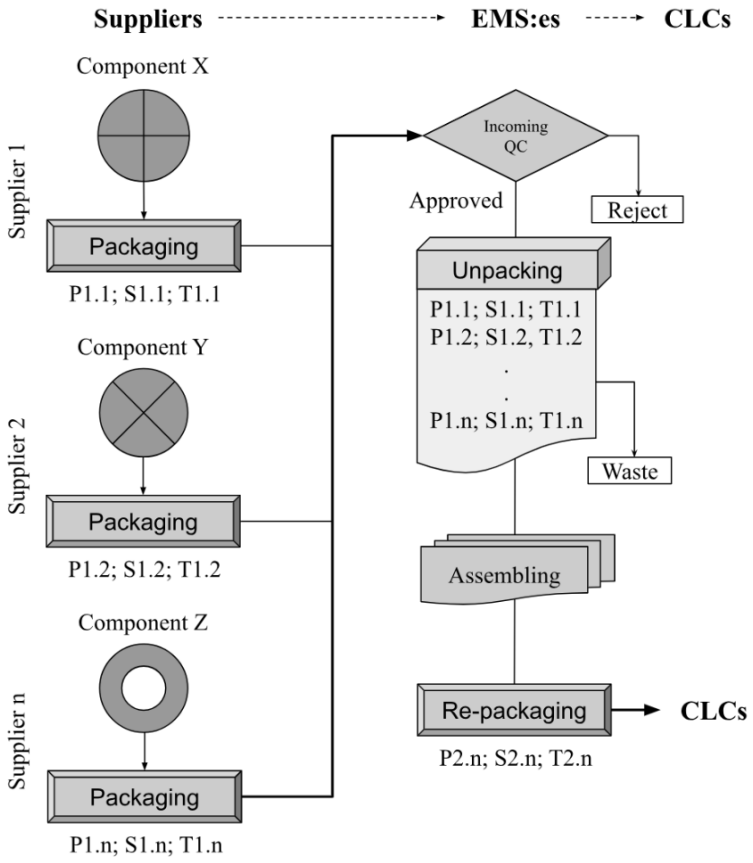

Figure 4.6: Packaging flow diagram

After discussing with various internal stakeholders, it was noticed that this packaging waste generation triggered the warning amongst the commodity managers and environment team at the case company. As Axis is not designing or developing any packaging upstream of the supply chain, the only control they have over this packaging and packaging waste is through their quality control requirements, which are not strict at the moment.

4.2.3 Packaging Decision-making

Before understanding how packaging decision-making works at Axis, it is important to know what the supplier selection process looks like. If any company wants to have a sustainable supply chain, efforts should be taken from the very beginning, like at the stage of supplier selection (Cole & Atiken, 2019). When selecting suppliers, Axis conducts supplier assessment, jointly led by the Quality, sourcing,

and environment teams as shown in Figure 4.7. During the assessment, various factors are checked like quality, capacity, price, etc. and one of the factors is the packaging.

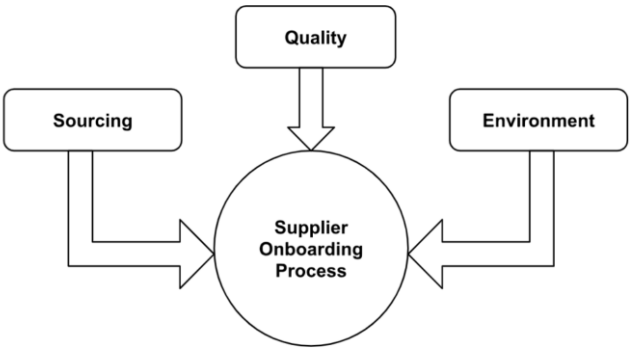

Figure 4.7: Supplier Selection

During these assessments, it is checked that suppliers adhere to the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH), Restriction of Hazardous Substances in Electrical and Electronic Equipment (ROHS), and Forest Stewardship Council (FSC) directives which are mandatory to have certification for. Apart from these, there are no other explicit packaging requirements for suppliers to fulfill. Once a supplier is onboarded, it gets audited every 3 years to ensure the said standards are still being met by the suppliers. After onboarding, suppliers get involved in the product development phase as per the requirements of the projects. It is good practice to involve suppliers in the development process in the early stages as this minimizes the operational risks (Wieteska, 2020). The product development phase at Axis starts with concept creation, followed by the creation of test build, and mass production approval. This can be illustrated as follows.

As illustrated in Figure 4.8, the initial phase of project development at Axis begins with concept building. At this stage, Axis develops various initial concepts and asks suppliers to provide prototypes as if these concepts were final. Multiple concepts (denoted as 'n') may be developed, with suppliers requested to produce 'n' prototypes along with their corresponding packaging.

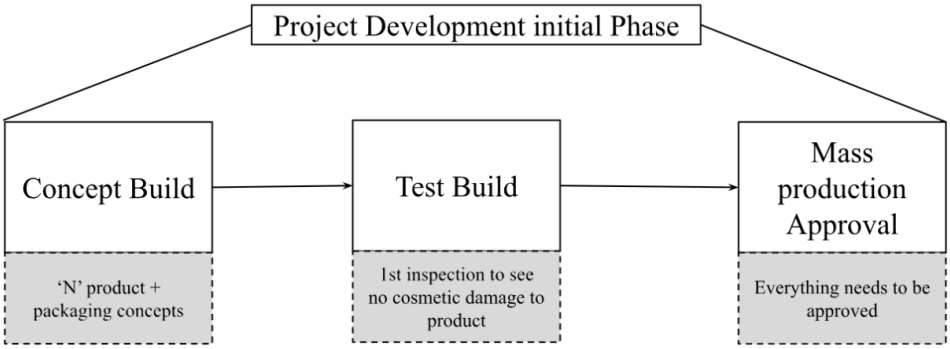

Figure 4.8: Product development process at Axis

After reviewing these concepts, they move to the test build stage, where tests are conducted. During this stage, the packaging is inspected to ensure it protects the product and prevents cosmetic damage. This is the only point in the process where packaging undergoes a thorough review. The Sourcing team checks quality and cost, the Environmental team ensures no harmful materials are present and verifies relevant declarations. However, there is a notable absence of tests focusing on packaging strength or other packaging-specific features.

Once approved at this stage, the packaging is documented for the specific part. In the final stage, the packaging is tested again, focusing on secondary and tertiary packaging to verify its protective capability. The product along with its packaging must be approved at this stage, as responsibility then transfers to the EMSs (Electronic Manufacturing Services) for further quality inspections during actual production. Currently, suppliers are entrusted with the responsibility of ensuring safe packaging and are given the liberty to select packaging materials, provided they meet specified safety requirements.

5. Regulatory Review

This chapter will examine and analyze the relevant regulatory frameworks and compliance requirements in various markets. This analysis will explore compliance strategies employed by industry leaders. Potential upcoming regulatory changes and their impact on future practices and operations will be discussed as well. In the research framework, it is highlighted as shown in Figure 5.1 below.

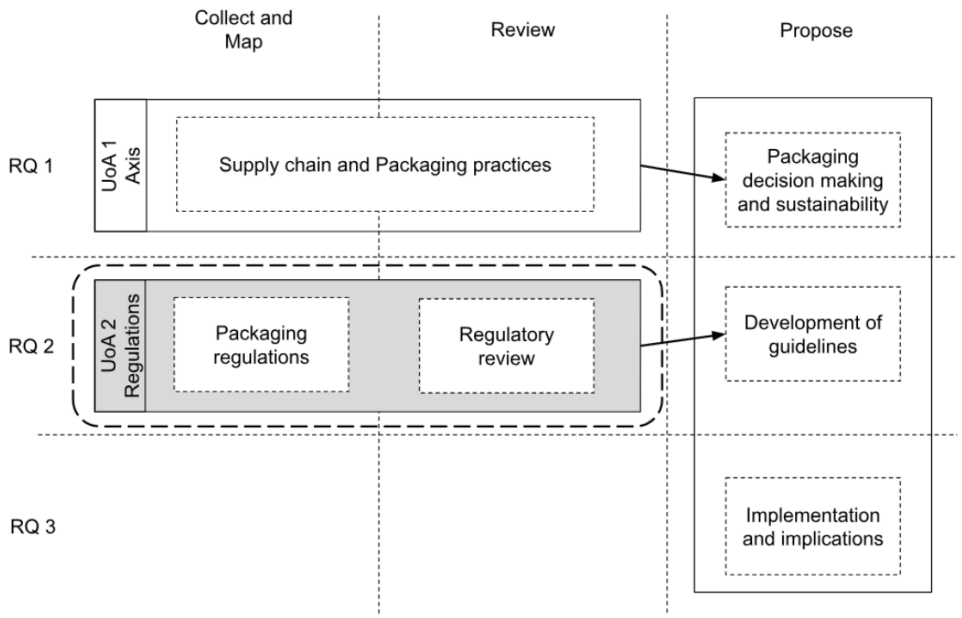

Figure 5.1: Research framework

5.1 Overview of packaging regulations across countries

Table 5.1 gives an overview of packaging regulations passed in different countries.

Table 5.1: Overview of country profile regarding packaging regulations

Initiative	*France*	*Spain*	*Germany*	*California*	*Canada*	*EU PPWD*
Ban on single-use plastics	By 2040				Sale, manufacture, import, and export of different applications prohibited from 2022	
EPR	Producers, importers, and distributors must contribute to waste management	One of few countries to apply it to industrial and commercial packaging Separate waste collection targets of 75% by 2027, 85% by 2030, 95% by 2035	Mandatory participation in take-back programs At least 50% by weight of total waste collected to be recycled	PROs must create a plan to achieve a 25% reduction in weight and plastic components by 2032. Producers should demonstrate a 65% recycling rate for three consecutive years until 2027 and a 70% rate thereafter.	By 2030, EPR policies will be widespread, expanding collection programs, incentivizing recycling-friendly designs, and improving recycling infrastructure for plastic packaging and SUPs.	
Recycling Targets	65% by 2025	65% by 2025; 70% by 2030	70% from 2022			By 2025, 65% of packaging waste by weight must be recycled; by 2030, it should reach 70%.
Plastic Recycling Target	55% by 2025	55% by 2030	63% from 2022	30% by 2028; 40% by 2030; 65% by 2032	55% by 2030	55% by 2030
Recycled content in plastic packaging		20% reduction by 2025, 30% by 2030; 15% for primary-use plastic films; 30% for secondary/tertiary packaging films; & 60%			50% by 2030	

Initiative	*France*	*Spain*	*Germany*	*California*	*Canada*	*EU PPWD*
		for items like pallets and containers.				
Reduction in packaging waste produced		13% in 2025; 15% in 2030; compared to 2010		PRO must reduce plastic-covered material by 10% by 2027 and 20% by 2030.		
Ensuring packaging is recyclable, when possible, reusable		By 2030		By 2032	By 2040	
Paper, paperboard, and cardboard recycling targets		75% by 2025 85% by 2030	90% from 2022			75%

5.2 Packaging Regulations

This section provides an overview of the various regulations surrounding packaging and packaging waste. Through the systematic examination of the data, the study aims to contribute to the broader outlook of regulatory frameworks. These regulations are intended to enforce new requirements with the principal aim of limiting the negative impact of packaging on the environment. The empirical investigation would serve as a foundation to develop the packaging guidelines. Most regulations across the countries tackle elements like packaging specifications, attributes of packaging, and packaging chain. Understanding regulations on a global scale can be challenging and different aspects emerge when examining the landscape as shown in Figure 5.2.

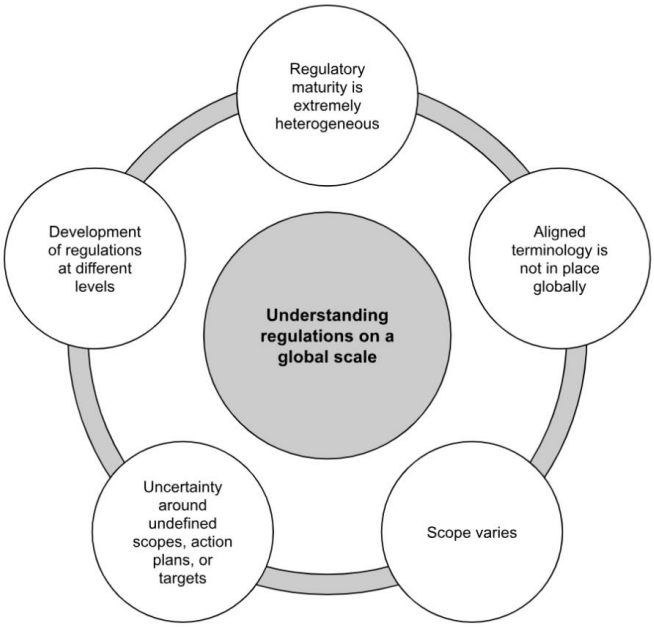

Figure 5.2: Understanding packaging regulations on a global scale

5.2.1 Packaging and Packaging Waste Directive

The directive on packaging and packaging waste (94/62/EC) defined specific objectives in terms of packaging waste management, and environmental protection; harmonizing national regulations concerning packaging and packaging waste and contributing to the enforcement of the EPR mechanism (Tencati et al., 2016). The policy applies the "EU waste hierarchy", set up by the EU waste framework directive (European Commission, 2023) as shown in Figure 5.3.

Figure 5.3: EU waste priority order (European Commission, 2023)

The most favorable option in the hierarchy is to reduce the amount of produced waste with a reduction of raw material inputs or reduction of waste outputs (Ewijk & Stegemann, 2016). The goal would be to generate zero waste, yet this is reasonably challenging in terms of packaging material. If reduction is not possible, the second option is to use materials repeatedly. Material reuse is essential for a circular economy, and it prevents further damage to the environment, additionally reusing the packages has a significant impact on preventing waste production (CNE, 2018). The third option in the waste hierarchy is recycling, meaning the material is used for making new products. However, this option requires additional resources and energy to process the material and generate the desired new material. The second last option in the framework is recovery, where energy is recovered from waste for example through incineration. In this case, the energy recovered can be only used once and the material circularity is reduced (Pires & Martinho, 2019). The least favorable option is disposing of waste in landfill, and this should be avoided to the last.

The latest version of the directive, amended in 2018 aims to reduce the disposal of packaging waste and promote a more circular economy. It covers all the packaging and packaging waste regardless of the materials used. The PPWD sets recovery and recycling targets for packaging waste, these targets are reviewed, and newer ones are proposed. The directive also sets out the essential requirements with which all packaging on the EU market must comply.

The Directive of the European Parliament (2019) regarding plastic products focuses on reducing the impact of certain plastic products on the environment and also requires member states to take measures to achieve a reduction in the consumption of single-use plastics. European Commission (2017) stressed that it would work towards all plastic packaging being recyclable by 2030. The European Green Deal (European Commission, 2019) would develop the requirements to ensure all packaging in the EU market is reusable or recyclable in an economical manner by 2030. It included targets and measures to tackle over-packaging and waste generation. The circular action plan from the European Commission (2020) would concern the entire life cycle of products, from design and manufacturing to consumption, repair, recycling, and bringing resources back into the economy.

5.2.2 Packaging and Packaging Waste Regulation

The PPWD directive was subjected to changes and a draft regulation was tabled in 2022. In this amendment, the proposal takes the form of a regulation rather than a

directive, aiming to ensure that all member states fulfill their obligations at the same time and in the same way. The regulatory failures of the current directive, such as delays, incorrect translation into national law, poorly designed, hard to enforce, and unevenly applied essential requirements and difficulties of the member states to ensure compliance with national recycling targets revealed that harmonization is necessary in the form of a regulation, rather than simply revising the current directive (European Parliament, 2018). The new regulations introduce minimum recycled content targets for the plastic part in packaging, requirements for packaging minimization, EPR for packaging that the packaging producers sell, and tackling excessive packaging.

The EU Member States were supposed to develop their legislation, which should have been complemented with the elements that have not been elaborated on the EU level. This task appeared to be complicated for many countries for various reasons. The cost of implementation of the directive can be high for a country, especially if it is not done carefully. As a result, the state of implementation of the directive by the EU countries remains non-uniform. Only a few countries have fully implemented it, while others have just transferred the requirements into their legislation but have not implemented the obligatory enforcement measures. This study initiated with studying the regulations from the countries and regions in which the case company has its biggest presence, but also, to have a holistic view, studies some other countries with detailed regulations addressing this issue.

5.2.3 France

The main decrees and orders related to waste prevention and management are regulated by the French Environmental Code (FEC). France has long applied EPR; producers, importers, and distributors in the sectors covered by an EPR scheme are required to financially contribute to the management of the waste generated by their products by paying to an eco-organisation.

France's legislation has combated plastic notably by targeting bans on several plastic products. The commitment to ban single-use plastics by 2040, as outlined in the Anti-Waste Law (Ministère de la Transition écologique et solidaire, 2020), is a significant aspect of these regulations. This initiative seeks to curb the environmental impact of disposable plastics and encourage the adoption of more sustainable alternatives (Cloché-Dubois et al., 2023). Specific targets for plastic recycling are outlined, addressing the need to increase the recycling rates of plastic materials.

Regulations specify standards for the composition of packaging materials, particularly regarding recovered and sorted paper and cardboard. Regulations mandate that packaging should be designed to facilitate reuse, recycling, energy recovery, composting, or biodegradation. This approach encourages sustainable packaging practices and discourages the use of materials that are difficult to recycle or dispose of responsibly.

When it comes to recycling targets, France was very ambitious and pledged that they would attain a recycling rate of 55% by 2020 and 65% by 2025. The European target was set to 55% by 2025, then 60% by 2030 and 65% by 2035 (Legifrance, 2024). Although France had pledged to go faster, it reached a ceiling of 42% and hence failed to meet the objective, suggesting that being over-ambitious is not the approach. Table 5.2 gives a summary of France regulations related to packaging.

Table 5.2: France targets

Initiative	***Target***
Ban on single-use plastics	By 2040
Recovered paperboard ● Amount of non-paper components in % max by mass ● Amount of unwanted material in % max by mass	 ● 0.25 to 1.5 ● 0.5 to 3
EPR	Producers, importers, and distributors must contribute to waste management
Minimum portion of reused packaging to be placed on the market annually	From 5% to 10% based on the annual turnover of the producers between 2023 and 2027
Recycling Targets	65% by 2025
Plastic Recycling Target	55% by 2025
Public procurement	Requires recycled materials in proportions of 20% to 100% depending on the type of product

5.2.4 Spain

Spain issued the Royal Decree 1055/2022 to prevent and reduce the impact of packaging and packaging waste. The main purpose of this new decree was to make all packaging on the market recyclable by 2030 and, where possible, reusable (KPMG, 2023). It seeks to align Spain's packaging legislation with the new extended producer responsibility scheme set in place by the EU. The Decree states and includes "industrial packaging", "commercial packaging" and "service packaging".

The Royal Decree establishes prevention targets, which are to be measured as the reduction in weight of packaging waste produced concerning that generated in 2010. These targets are set at 13% for 2025 and 15% in 2030. The Royal Decree incorporates the recycling targets established in Directive (EU) 2018/852 of the European Parliament and the Council, 2018, amending Directive 2008/98/EC on waste (European Commission, 1994). This measure aims not only to increase the degree of recovery of materials contained in packaging waste but also to ensure that recovered materials are of the highest possible quality with a view to their safe reintroduction into the productive cycle, including the packaging production cycle.

The rules for handling packaging waste have changed in Spain. Before, only household packaging was included. Now, commercial, and industrial packaging are also covered. By 2025, a minimum of 65% by weight of all packaging waste will be recycled, and 70% by 2030. In addition, packaging design and marking obligations are established, which include how to indicate the reusable nature of the packaging, the category to which the packaging belongs, or the container in which it should be deposited once it becomes waste. Spain implements a bonus system for packaging marked with the percentage of packaging material, providing incentives for quality recycling. A minimum bonus of 10% will be granted to containers that are marked with the percentage of packaging material, including its components, available for quality recycling. A bonus will be granted to plastic packaging that incorporates at least 10% additional to the mandatory minimum content of recycled plastic, provided that the recycled plastic comes from packaging waste. Penalties are imposed for non-compliance with regulations, including requirements for specific packaging materials and their recycled content.

In 2030 product producers will try to ensure that the packaging made with non-compostable plastic that they put on the market reaches the required percentage of recycled plastic content. Within the framework of public procurement, public administrations will include the acquisition of products in reusable and easily

recyclable packaging, or in packaging made with recycled materials, whose quality meets the required technical specifications (Spain Boletín Oficial del Estado, 2022). Table 5.3 gives a summary of Spain's regulations related to packaging.

Table 5.3: Spain's targets

Initiative	***Target***
Recycled content in plastic packaging	20% by 2025 30% by 2030 15% for plastic films in primary applications including bagging, linings, wrapper 30% for plastic films used in secondary and tertiary packaging 60% for pallets, boxes, storage containers, envelopes, and other similar plastic items packaging
Reduction in packaging waste produced	13% in 2025 15% in 2030; compared to 2010
EPR	One of few countries to apply it to industrial and commercial packaging Separate waste collection targets of 75% by 2027, 85% by 2030, 95% by 2035
Ensure all packaging placed on the market is recyclable, and whenever possible reusable	By 2030
Recycling Targets	65% by 2025 70% by 2030
Plastic Recycling	55% by 2030
Bonus	Granted if plastic packaging incorporates an additional 10% of the mandatory minimum content specified

5.2.5 Germany

The packaging law (Bundesgesetzblatt, n.d.) defines obligations for manufacturers and distributors. Manufacturers, including importers, are mandated to annually declare all packaging materials placed in the market, detailing types, and masses. It

sets requirements for product responsibility for packaging per the Circular Economy Act. Additionally, they must participate in take-back programs to fulfill their recycling goals. Failure to comply may result in administrative fines of up to €200,000 (VERPACKG, n.d.).

Distributors, including final distributors, are equally obligated to accept and recycle used packaging materials, ensuring their return to the market in a similar form. Compliance verification mechanisms are in place to monitor adherence to these obligations. Manufacturers and distributors are not permitted to organize the return and recycling of their packaging individually but are obligated to participate in a permitted packaging scheme. The selected packaging scheme then organizes the collection, sorting, and recycling of the packaging nationwide.

Traders affected by the VerpackG have the responsibility to participate in the recycling of their packaging. Incidentally, the packaging licensing obligation does not apply to the B2B sector. In fact, the VerpackG mainly concerns the B2C business (Grabowska, 2021). The requirements set by Germany are quite vague and, in many places, do not specify any numbers regarding targets, rather state that the packaging is to be limited and kept to minimum levels. Table 5.4 gives a summary of Germany's regulations related to packaging.

Table 5.4: Germany's targets

Initiative	***Target***
Plastic recycling targets (Mechanical recycling)	63% from 2022
Other composite recycling targets	70% from 2022
Paper, paperboard, and cardboard recycling targets	90% from 2022
Plastics must be recycled	At least 90% by 2022
EPR	Mandatory participation in take-back programs At least 50% by weight of total waste collected to be recycled
Penalties	Up to €200,000 for non-compliance of recycling goals

5.2.6 California

California legislation indicates that rigid plastic packaging containers sold or offered for sale in California must meet specific criteria outlined in the legislation. These criteria include being made from a minimum of 25% post-consumer material, achieving a recycling rate of 45%, and being reusable or refillable (California Legislative Information, n.d.). The framework in California aims to shift the burden of costs associated with collecting, processing, and recycling materials from local jurisdictions to producers of the material. Producers of single-use packaging are mandated to take responsibility for end-of-life management costs and ensure the recyclability or compostability of their materials.

Specific recycling rate requirements are set for covered materials sold or distributed in California. Additionally, PROs are tasked with developing and implementing plans to achieve weight reduction. These requirements underscore the state's commitment to promoting recycling and reducing waste. The legislation also emphasizes source reduction as a key strategy for minimizing waste. PROs are required to source and reduce the percentage of plastic-covered material sold or distributed in the state by participant producers. By January 1, 2027, a minimum of 10% of plastic-covered material must be source-reduced, with a portion shifted to reusable or refillable packaging systems. By January 1, 2030, this requirement will increase to 20%, further encouraging sustainable packaging practices.

To ensure compliance with packaging regulations, penalties are imposed on violators, including PROs. Penalties may include fines of $50,000 per day per violation, with higher penalties for specific violations related to rigid plastics. Moreover, producers are required to ensure that all covered materials offered for sale in the state are recyclable. Table 5.5 gives a summary of California regulations related to packaging.

Table 5.5: California targets

Initiative	***Target***
Rigid plastic packaging	Made of 25% post-consumer material Have a recycling rate of 45%
EPR	Shift the burden of costs to collect, process, and recycle materials from local jurisdiction to producers of the material A very detailed implementation plan for PROs

Initiative	*Target*
	A producer should demonstrate a 65% recycling rate for 3 consecutive years until 2027 and a 70% recycling rate after 2027 PROs to develop and implement a plan to achieve a 25% reduction by weight and 25% by plastic component source reduction by 2032
Packaging reduction	PRO shall source reduce no less than 10 percent of plastic-covered material sold by 2027 PRO shall source reduce no less than 20 percent of plastic-covered material sold by 2030
Penalties	Up to $100,000 per day per violation
Ensure all packaging offered for sale, distributed, or imported is recyclable or compostable	By 2032
Plastic recycling targets	30% by 2028 40% by 2030 65% by 2032

5.2.7 Canada

The Canadian law mentions timelines coming into force dates for different SUPs and activities in Canada. The Government of Canada has set ambitious targets for plastic packaging, mandating that it contains at least 50% recycled content by 2030. This target is in line with the Zero Plastic Waste Policy (Government of Canada, 2023), emphasizing the country's commitment to reducing plastic waste and promoting a circular economy. Canada aims to achieve significant milestones in plastic packaging recycling and recovery. The country is working towards at least 50% recycled content in plastic packaging by 2030 and aims to collaborate with the industry towards 100% reusable, recyclable, or recoverable plastics. Additionally, efforts are underway to recycle and reuse plastic packaging and recover all plastics, as outlined in the Ocean Plastics Charter (Government of Canada, 2021).

EPR policies are a key feature of Canada's approach to managing packaging waste. Provinces in Canada have taken the lead in developing and implementing EPR policies, which hold producers responsible for the collection and management of

products and packaging at the end of their life. These policies encompass various measures, including take-back programs, curbside collection systems, and deposit-refund schemes. By 2030, it is expected that EPR policies for packaging will be in place nationwide, expanding collection programs, incentivizing design for recycling, and improving recycling infrastructure.

Plastic packaging in Canada is categorized into two broad categories: rigid and flexible. Rigid packaging refers to packaging whose shape remains essentially unchanged after the contents are added or removed, while flexible packaging is designed to change shape under tension or heat (e.g., shrink film, bags, pouches). Plastic packaging and single-use plastics constitute a significant portion of the Canadian plastics economy, but recycling rates remain low. Labeling rules are being introduced to provide clarity and transparency to consumers (Government of Canada, 2023).

The 2018 outcomes show only a 14% recycling rate, but to achieve a zero plastic waste target this needs to be closer to 65%. The major issue in Canada is the poor collection rate of waste with only 19% of waste being collected compared to the required 90% to achieve the target. Canadian Council of Ministers of the Environment (CCME) jurisdictions in identifying six priority action areas. These action areas include:

1. extended producer responsibility
2. single-use and disposable products
3. national performance requirements and standards
4. incentives for a circular economy
5. infrastructure and innovation investments
6. public procurement and green operations

Table 5.6 gives a summary of Canadian regulations related to packaging.

Table 5.6: Canada targets

Initiative	***Target***
Eliminate single-use plastics	Sale, manufacture, import, and export of different applications prohibited from 2022
Recycled content in plastic packaging	50% by 2030
EPR	EPR policies for packaging will be in place in most if not all provinces and territories by 2030.

Initiative	*Target*
	Expand collection programs for products that would be covered by these regulations Incentivize design for recycling, and improve recycling infrastructure for plastic packaging and SUPs
Recycle and reuse	At least 55% of plastic packaging by 2030
Recover	100% of all plastics by 2040

5.2.8 Others

Further review of regulations in other countries was carried out up to a certain level. Swedish packaging regulations have stringent requirements aimed at promoting sustainability and waste reduction. Producers must ensure that single-use plastic packaging contains a minimum of 30% recycled plastic. Aims for over 75% by weight of material used in packaging can be recycled and 50% of plastic packaging (European Environment Agency, 2022). PROs impose higher financial contributions based on the quality of packaging. New Jersey has set restrictions on polystyrene loose-fill packaging, contributing to waste reduction efforts (State of New Jersey, 2022). Mexico has started banning single-use plastics for certain applications since 2021. They have a high waste collection rate but most of it is improperly disposed of, leaving them with one of the lowest recycling rates (Griffin & Karasik, 2022). Japan also focuses on reducing single-use plastics through measures like design for the environment, ensuring a high percentage of containers and packaging are reused or recycled (Ministry of the Environment, Government of Japan, 2021)

5.3 Global Trends and Patterns in Packaging Legislations

A comparative study was conducted following the review of literature and packaging laws in each of the countries. Based on the regulations discussed, several common patterns and regulatory trends emerge. These themes and trends were identified and categorized to form a broader picture of the packaging regulatory landscape. The different aspects are shown in Table 5.7.

Table 5.7: Different aspects of packaging regulations

Aspect	*Description*	*Key Points*	*Relation*
Circular Economy	Shift from a linear to a circular economy, focusing on resource efficiency, waste reduction, reuse, and recycling.	Emphasis on design for recycling, minimum recycled content, and use of recycled. Policies aim to prevent waste, ensure proper collection, and facilitate recycling.	Underpins source reduction, EPR, recycling targets, and reusability. Encourages sustainable packaging practices.
Source Reduction	Reducing packaging waste at the source by minimizing volume, mass, or toxicity.	Focus on minimal packaging and sustainable material choices. Bans on usage of certain materials.	Integral to circular economy principles. Supports EPR by reducing overall waste.
EPR	Producers are responsible for the lifecycle of packaging materials, including collection, recycling, and disposal.	Producers manage waste or join PROs. Challenges in defining responsibilities and ensuring compliance.	Encourages producers to design for recyclability and reusability. Supports recycling targets by ensuring producer accountability.
Recycling Targets	Setting specific targets for overall recycling, amount of recycled content in plastics and recovery of packaging waste.	Targets vary by material and country. Issues with quality and safety of recycled materials.	Reinforces circular economy by ensuring materials are reused and recycled. Supported by EPR schemes which provide necessary incentives.
Reusability	Promoting the reuse of packaging materials.	Targets for secondary and tertiary packaging reusability.	Central to a circular economy by extending packaging life cycle. Aligns with source reduction by

Aspect	*Description*	*Key Points*	*Relation*
			minimizing new material use.
Space Utilization	Ensuring efficient use of space in packaging to reduce costs and environmental impact.	Minimize empty space in packaging.	Supports source reduction by optimizing packaging design. Reduces transportation inefficiencies, aligning with broader sustainability goals.

5.3.1 Transition towards a Circular Economy

A principle that emerges strongly from the various approaches and legislative efforts to address the growth in packaging and packaging waste is the development of an increasingly circular approach. All countries share a common vision of transitioning towards a circular economy. The EU promotes the concept of a circular economy as a sustainable alternative to traditional linear economic models. It has adopted various strategic documents and action plans, such as the Circular Economy Action Plans and the European Green Deal, to transition towards a circular economy. Countries like Canada and Germany incentivize a circular economy (Garcia & Rivas, 2021; Government of Canada, 2023; VerpackG, 2019). Circular economy principles are central to the waste management strategies of these countries focusing on resource efficiency, waste reduction, and promoting reuse and recycling of materials.

Regulations in France, Germany, and the EU emphasize promoting the circularity of plastics through measures like a design for recycling, minimum recycled content requirements, and encouraging the use of recycled materials in packaging. Some of the policies are preventive; aimed at reducing the quantity of packaging entering into circulation. Others are intended to ensure that packaging in circulation doesn't leak into the environment, is properly collected and all residual value is recovered through energy recovery or recycling. Some of the policies allow for the reintroduction of packaging material back into packaging use.

Figure 5.4 shows the circular material use rate over the years. In 2022, the EU's circular material use rate reached 11.5%, meaning that 11.5% of material resources

used in the EU came from recycled waste materials. Compared with 2021, the circularity rate increased by 0.1 percentage points. Between 2010 and 2022, the rate increased by 0.8 pp from 10.7% to 11.5%. The EU aims to double its use of recycled material between 2020 and 2030 (European Environment Agency, 2024).

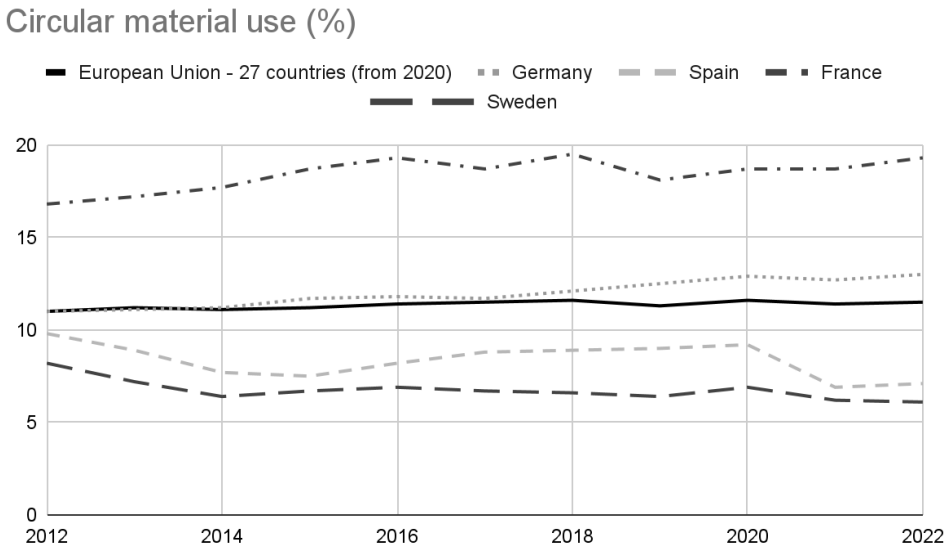

Figure 5.4: Circular material use rate in the EU (Eurostat, 2023)

Although the circular economy has been identified as a prerequisite to sustainability, limited empirical evidence exists on the effectiveness of environmental sustainability. It is paramount for businesses to categorize materials as a waste or a resource when transitioning to a circular economy (Greer et al., 2021). The categorization depends on the context, influenced by various factors including perspectives, practicality, cultural, geographical, and legal frameworks. Companies must recognize that what is considered waste in one context might be a valuable resource in another.

Some circular innovations might inadvertently sustain linear economy practices. For example, efforts to keep materials in the economy longer could lead to increased overall material use and energy demand, counteracting the benefits of circular practices (Pires & Martinho, 2019). Businesses must think about how their circular initiatives will affect them across their whole lifecycle. Eventually, the costs of refining circular material flows may outweigh the benefits. Circular innovations must also address potential risks to human health (Greer et al., 2021). Ensuring

safety in recycling processes and the use of secondary materials is crucial to maintaining public trust and compliance with health regulations.

There is a need for policymakers to promote business with strategies and practices that facilitate the transition from a linear economy to a circular economy (Hailemariam & Erdiaw-Kwasie, 2022). Setting up supportive institutions and infrastructure that will aid the transition, communication of relevant knowledge and information that would relate to business objectives and strategies and a stronger regulatory framework will drive the businesses.

5.3.2 Source Reduction

Prevention of waste is a priority, representing the first option in the management hierarchy. The European Commission reaffirms the strategic importance of waste prevention in the context of circular through the implementation of regulation instruments, implementation of voluntary agreements, and implementation of information measures. A technique used to control waste is by eliminating the waste before it is created, or by using less material to get the job done. This is reducing the generation of waste at the source (Maryland Department of Environment, n.d.).

The EU has set packaging reduction targets of 5% by 2030, 10% by 2035, and 15% by 2040 compared to 2010. The concept of source reduction has also been stated and discussed in the regulations of various other countries. Another way of reducing packaging at its source is by avoiding the use of certain materials. Several countries including France, Canada, and Mexico have implemented bans or restrictions on single-use plastics. Regulations are in place to phase out certain single-use plastics and promote more sustainable alternatives. This ban is currently mostly directed towards consumer packaging which in the future could be extended to industrial packaging. While France aims to ban single-use plastics by 2040 (Legifrance, 2024), Mexico has introduced a ban on single-use plastics in 2021. Canada on the other hand is planning to restrict usage of SUP in phases over the period from 2022 - 2025 (Government of Canada, 2022). Germany and California also emphasize reducing single-use plastics through measures like design for the environment and encouraging minimized plastic packaging. New Jersey has placed restrictions on polystyrene loose-fill packaging.

Source reduction of packaging is understood as efforts aimed at reducing packaging volume, mass, or toxicity throughout the life cycle. It covers the design, manufacture, use, and disposal of packaging with minimum toxic content and minimum volume of material. A variety of packaging source reduction policies exist

in the EU, which have been developed by the Member States trying to fit them to the country's legislation, institutional infrastructure, conduct of the industry, etc. Varžinskas et al. (2016) state this as a problem when there is transfer from one country to another.

However, reports suggest that '…there is a large gap between the Member States and the industry concerning implementation and compliance of packaging with the requirements. For the industry, the most important effect of the requirements is not the reduction of packaging (waste), but the free movement of packaging. The issue that has received the most attention is indeed the avoidance of over-packaging (Varžinskas et al. 2016; Sluisveld & Worrell, 2013). Companies must view material minimization as a means for achieving economic superiority in business competition. Integration of source reduction measures with other systems in a company's supply chain might lead to a significant reduction in its total cost.

5.3.3 EPR

EPR is a policy tool that can extend the packaging producer's full or partial financial and operational responsibility for the packaging materials (Watkins et al., 2017). Such obligations are imposed by the government requiring producers to establish, contribute, or participate in the financial and operational responsibility of the collection, recycling, recovery, or disposal of packaging material. Producers and importers may be required to meet these obligations. Figure 5.5 depicts the role of PROs in the supply chain.

Figure 5.5: EPR in the packaging stream

Most countries have two models of EPR systems. The company that wishes to do business in the country has the option to be responsible for its activities of ensuring that the waste generated at the end of the lifecycle of the product is recycled. The other option is that the company passes on its responsibilities of processing waste to a producer responsibility organization (PRO). In this case, it is the responsibility of the PRO to ensure that waste is being recycled and the recycling targets are being met. Smaller companies will have relatively more difficulty organizing their take-back systems than larger firms, hence the PROs will remove what would otherwise be relatively high burdens on smaller firms.

Producers can address their take-back obligations by paying material-specific fees to EPR schemes (Joltreau, 2022). These fees determined and monitored by PROs are charged based on the weight of packaging the producer puts on the market and consequently incentivize material optimization (Bassi et al., 2020).

EPR programs have often included recycling and recovery targets. The role of each actor in the EPR system can be quite confusing (WEEEForum, 2020). Ideally, it is the producer who is in the best position to make changes to their products to meet the objectives of the EPR program. However, in some cases, it is ambiguous who exactly is the producer in the value chain. It can be the firm whose name is on the product itself, or it can be the supplier who produces the packaging material, it can even be the outsourcing party who manufactures on behalf of the firm. Even if the firm decides to share responsibility it is difficult to assign which actor takes responsibility for which part of the chain.

Failure to comply with EPR requirements could have serious impacts on producers, such as sales blocks, fines, and negative media. EPR is intended to provide economic incentives for producers to improve the design of their products; however, there are several obstacles to achieving this (Mayers, 2008).

5.3.4 Recycling Targets

A critical aspect of a good packaging waste policy is the introduction of targets for the reuse, recycling, and recovery of packaging waste. The inclusion of targets is an integral part of waste management plans globally. The EU Packaging and Packaging Waste Directive sets out recovery and recycling targets and deadlines for each of the EU member states and obliges them to address the recovery and recycling of used packaging.

The setting of targets for each of the different solutions also establishes a hierarchy of priorities – for instance, in Germany, high recycling targets and the limits of incineration with energy recovery were responsible for recycling technology innovation. In France, there was no distinction made between material recycling and energy recovery until an ordinance introduced the waste hierarchy. Targets for recycling can vary following the type of material for particular packaging types. However, the challenges raised with the use of recycled content are the quality of the recycled content and whether the recycling technologies used are adequately safe for contact materials.

Japan follows Spain's ideology of ensuring 100% of plastics are reused or recycled by 2035. The current recycling rate of packaging in the EU is shown in Figure 5.6. Germany and Spain are in the frame to meet the 2025 targets.

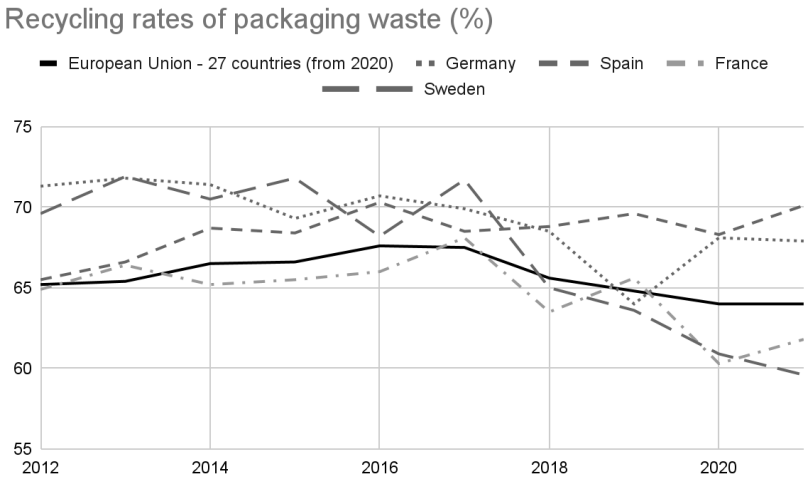

Figure 5.6: Recycling rate of packaging in the EU (Eurostat, 2023)

The legislation in various countries stipulates the minimum percentage of recycled content required in recycled plastics used for packaging. The article of standardization in the EU PPWD (European Commission, 1994), says that the commission shall promote, in particular, the preparation of European standards relating to: criteria for a minimum content of recycled material in packaging for appropriate types of packaging. In Spain, product producers need to ensure that the packaging made with non-compostable plastic that they put on the market has a recycled plastic content of 30% for plastic films used in secondary or tertiary packaging applications, such as shrink wrap, liners, bags, bubble; 60% for pallets,

boxes, drums and wholesale storage containers and other similar plastic items packaging, envelopes, among others.

A plastics packaging that is a single-use product may only be placed on the Swedish market by a producer if the disposable packaging contains at least 30% recycled plastic. Rigid plastic packaging sold in California should be made from 25% post-consumer material. Canada is ambitious when it comes to recycling the content of plastics, aiming for 50% recycled content by 2030. Japan is also actively working towards doubling the use of recycled plastics content by 2030 compared to 2019 levels. The recycling industry plays an important part in moving from a linear to a circular economy and higher recycling targets will prompt new challenges to waste management systems (Beccarello & Foggia, 2018).

It is essential to account for the quality of the source-segregated plastic. The new definition of the recycling rate of the European Union appears to be consistent with the environmental results (higher rate higher benefits), but the collection rate and the quantity of impurities in the source-segregated plastic bin can add some important information regarding the efficiency of the system (Bassi et al., 2020).

5.3.5 Reusability

The reusability of the packaging material is an integral part of the circular economy. The EU PPWR sets targets for secondary and tertiary packaging reusability. For transport packaging used for transporting products (pallets, boxes, trays, plastic crates, bulk containers, including pallet wrappings or straps), the minimum share of such packaging that is reusable in a system is 40% from 2030 and 70% from 2040. Similarly for grouped packaging, the minimum share of such packaging which is reusable packaging within a system is 10% by 2030 and 25% by 2040. Spain has its target of 20% in 2030 and 30% in 2035.

The France decree defines the minimum proportion of reused packaging to be placed on the market annually for the years 2023 to 2027. The requirement varies based on the annual turnover of the producers.

5.3.6 Space Utilization

Empty spaces during transportation lead to inefficiencies and extra costs within the supply chain. Concerning this empty air and excessive packaging, by 2030 operators filling the packaging in grouped packaging or transport packaging will have to

ensure that the empty space ratio is a maximum of 50%. It needs to be ensured that the empty space is reduced to the minimum necessary for ensuring packaging functionality, including product protection. This requirement is set by the EU PPWR. Other countries also speak about the goods-to-empty space ratio but only define it to be minimum and no specific numbers are mentioned.

Several questions are raised, especially those related to optimization methods of weight and volume of packaging. This needs to be clarified through the adoption of the EU Member States' legislation, establishing and describing the procedures to be followed to comply with the directive. Partly due to this, the state of implementation of the directive remains mixed across the EU Member States despite more than 25 years since the adoption of the Directive. Very few countries have implemented comprehensive national enforcement systems to supervise packaging and warrant its conformity with requirements. It is important for efficient supervision and enforcement that the requirements be uniformly understood and treated by both business entities and supervisors.

6. Results & Discussion

This chapter will combine both the findings of Uo1 and Uo2 analysis to propose guidelines for the case company to integrate them into their current practices. It will also address the implications of the regulations on the operations. The same is highlighted in the research framework in Figure 6.1 below.

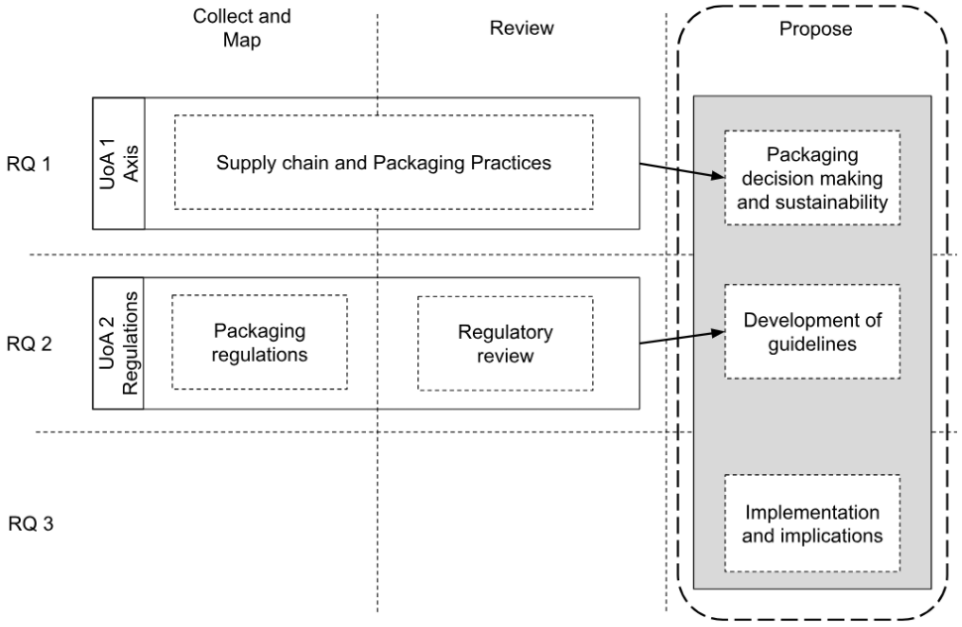

Figure 6.1: Research framework

6.1 Sustainability in Packaging Decision-Making

6.1.1 Perception and Strategic Importance

During interviews with commodity managers, it was noted that packaging is perceived as less sensitive in monetary terms and has a lower impact on Axis's profit, indicating it as a non-critical commodity as illustrated in the Kraljic matrix in Figure 6.2. But packaging's role in ensuring product quality and availability is crucial. Proper packaging is essential to prevent damage and ensure timely delivery, which indirectly supports overall profitability by maintaining product integrity and customer satisfaction (Narasimhan & Mendez, 2009). Thus, even though the packaging is categorized as a non-critical commodity based on expenditure, its actual strategic importance might be higher, placing it near the 'Leverage' quadrant in the matrix.

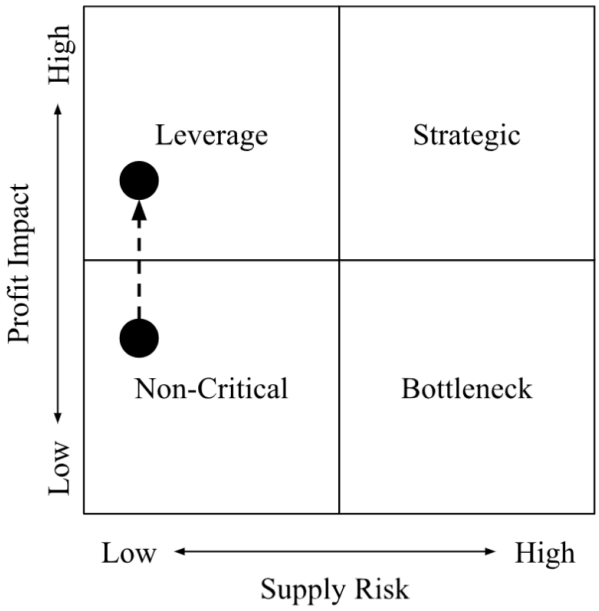

Figure 6.2: Packaging seen in matrix inspired by Kraljic (1983)

6.1.2 Sustainability efforts and Scope 3 emissions

Despite categorizing packaging as a non-critical product, interviews with some internal stakeholders indicate that there is a recognition of the high potential for

packaging to influence sustainability at Axis. Packaging has a high potential to influence sustainability (Boz et al., 2020). Recently, Axis built its in-house packaging capabilities for sales unit packaging, indicating that packaging sustainability has been on the agenda for several years. An interview with packaging engineers revealed that detailed attention is being paid to source reduction, such as reducing empty space and packaging sizes, and phasing out plastic materials wherever possible.

Since packaging activities fall under Scope 3 emissions of Science Based Targets, controlling them could help Axis manage these emissions. Although Scope 3 emissions targets are managerial ambitions, Axis needs solid plans to achieve these targets (Giesekam et al., 2021). Axis has set ambitions such as reducing the sizes of product packaging, increasing the use of renewable carbon-based plastics, and requiring their EMS and CLC operations to become fossil-free by 2030. Setting ambitious targets for packaging sustainability, based on regulatory frameworks and future developments, could significantly enhance Axis's environmental impact. These considerations will be discussed in detail in the recommendations section. This underlines the need for having a packaging control document based on regulations and targets, failing to do so may invite regulatory violations (Wilson et al., 2011).

6.1.3 Current Control Document Limitations

The current packaging control document at Axis only covers basic product security requirements without providing detailed specifics. Furthermore, it serves primarily as a sourcing necessity rather than encouraging continuous improvement in packaging. Upon further investigation, it was revealed that packaging upstream in the supply chain has not received sufficient attention. This is partly because packaging engineers are not involved in decision-making for upstream packaging, leaving the sourcing quality team responsible for creating control documents and conducting inspections.

6.2 Regulatory Influence on Packaging Decision-Making

Before creating guidelines, it is important to understand where in the decision-making process these regulations will show their influence and how, as it will help

to craft the guidelines more tailored in a way that they are relevant to the case company and also generalized to inspire other companies.

6.2.1 Integration in Decision-Making

In a context where multiple stakeholders with diverse backgrounds and interests are involved in packaging decisions, the focus tends to be on operational aspects and commercial feasibility, potentially overshadowing broader sustainability objectives (Koeijer et al., 2020). Currently, the actors involved in packaging decision-making at Axis are the same as previously shown in Figure 4.4, i.e. sourcing team, the quality team, which is part of the sourcing team, and the environmental team. However, a crucial missing actor is a packaging team, which can provide dedicated expertise on packaging aspects. This can be visualized in the illustration below Figure 6.3.

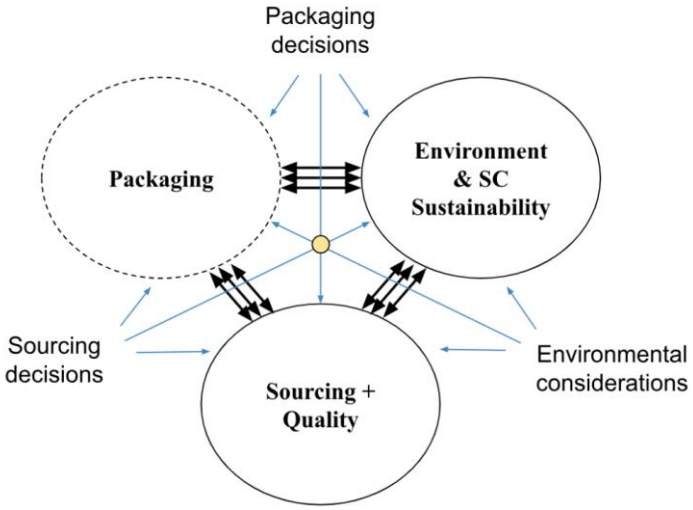

Figure 6.3: Decision framework

As illustrated in the diagram, effective packaging choices require input from the packaging team, sourcing team, and environmental team. The dotted boundary around the packaging shows its current absence from the decision-making process. The absence of inputs from the packaging team makes the current quality control document primarily a sourcing necessity. It is essential to have effective cooperation among all parties, considering how their decisions will affect each other. Companies should strive to achieve the "golden interaction" depicted in the figure, representing a perfect balance between all packaging-related decisions.

Currently, inputs from the Environmental team are limited to harmful substances and certification verification. Meanwhile, sourcing engineers follow the current control document with little motivation to improve packaging sustainability. This disparity highlights a lack of systems thinking, where packaging decisions are made without considering their impact on the entire supply chain, resulting in inefficient processes (Saghir, 2004). Hence, collaborative decision-making during the initial project development phase is crucial.

6.2.2 Optimal phase to implement packaging guidelines

There are approximately eight weeks between the test build and mass production approval; typically, around the third week, all parts and packaging get approved by the sourcing and environmental teams as shown in Figure 6.4. This phase is the optimal time to implement and use packaging guidelines. Since this might be the only instance where packaging receives focused attention, it is vital to craft guidelines that balance the interests of all stakeholders while meeting regulatory requirements. Packaging can be improved and made more sustainable through integrated and collaborative supply chain management (Azzi et al., 2012; Hellström et al., 2017).

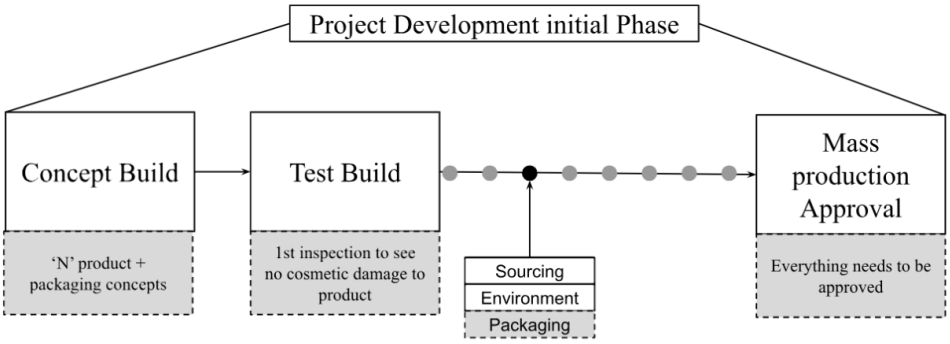

Figure 6.4: Product development process at Axis

As Axis involves suppliers early in product development, they can also motivate suppliers to improve their packaging. Enhanced collaboration with suppliers regarding packaging design practices is necessary. Not integrating suppliers and sub-suppliers in the supply chain can hinder packaging sustainability (Dominic, 2013). Mutual packaging development can enhance supply chain efficiency and cost-effectiveness (Sohrabpour et al., 2016), which is crucial for circularity.

6.2.3 How will it influence the decision-making process?

The implementation of new packaging regulations will alter the decision-making landscape at Axis. These advances will necessitate a more collaborative and integrated approach, with sustainability a crucial consideration from the start of product development.

6.2.3.1 Integrating Regulatory Compliance into Decision Making:

With the implementation of tougher packaging laws, compliance must become a critical consideration in decision-making. For example, rules requiring a certain amount of recycled content will force sourcing teams to prioritize products that match these criteria. These legal criteria must be considered throughout the early stages of product development, especially between the test build and mass production approval phases, to avoid costly redesigns and delays.

6.2.3.2 Enhanced Role of the Packaging Engineer:

A dedicated packaging engineer will be extremely helpful in managing these regulatory constraints. This position will not only give experience in packaging design and material selection, but it will also ensure that all decisions are compliant with regulatory requirements. The packaging engineer will contribute to the creation of a comprehensive picture of the supply chain by encouraging collaboration across the sourcing, environmental, and packaging teams, ensuring that all packaging decisions support larger sustainability goals.

6.2.3.3 Supplier collaboration and integration:

Early and proactive involvement of suppliers is critical for compliance. Axis must form strong partnerships with suppliers to co-develop regulatory-compliant packaging solutions. This partnership will entail exchanging best practices, establishing clear expectations, and monitoring compliance with regular audits and feedback sessions.

6.2.3.4 Financial and Operational Considerations:

New packaging restrictions have financial and operational repercussions. Axis should do rigorous cost-benefit assessments to better understand the economic implications of using new materials and processes. Furthermore, applying these standards will necessitate considerable operational changes, but they may be managed effectively with technology and strategic planning.

6.3 Development of Guidelines

Drawing from the analysis of packaging regulations across various countries, valuable insights have been gained into the evolving landscape of sustainable packaging. Key themes and trends identified include the transition towards a circular economy, emphasis on source reduction, implementation of EPR measures, and strict requirements for recycling and reusability. These insights provide a solid foundation for the development of guidelines aimed at addressing scope 3 emissions, promoting sustainable responsibility and resource efficiency throughout the packaging lifecycle. Leveraging the regulatory framework and empirical data a set of requirements for packaging can be imposed on the supplier.

As the previous sub-chapter identifies the commonalities between various regulations studies, now it is important to translate them into the regulatory framework for the packaging decision-making process. To do so, some considerations had to be made as there are various targets and limits for the same aspect among the various country regulations. While translating them into the guidelines, always highest or lowest asking levels, as per applicability, are set as requirements. This might sound ambitious, but it will fulfill the requirements for all the regions and the countries requiring them. While interviewing higher management and environmental engineers, it was reflected that Axis is ready to take it as a challenge, which makes it possible to set high targets in the requirements.

As regulations talk about many things, for the sake of these guidelines, only relevant targets are used. Also to not make it overwhelming in the first place, the proposed guidelines cover only critical factors based on the 9R framework for circularity given by Potting et al. (2017), which will make sure guidelines stick to the circularity. While reviewing the regulations, many of the countries set targets for and from 2030, hence proposed guidelines also aim for the year 2030. This also gives the case company and their suppliers sufficient time to adapt to the change. Even though these suggestions are limited and specific, they will make the current packaging regulations document more specific. Table 6.1 motivates the chosen guidelines.

Table 6.1: Motivation for guideline

Packaging Sustainability Guidelines		
Category	***Suggestion (With the horizon of 2030)***	***Motivation***
Refuse	Eliminate the use of single-use plastics.	France (2040) Mexico (2021) Canada New Jersey Japan
Redesign	Prioritize redesign of non-compliant packaging.	PPWR Japan (Design for the environment) by 2025 Canada (Design for recycling)
Reduce	Reduce packaging weight by 20% without compromising functionality.	PPWR - 5% (2030); 10% (2035); 15% (2040) California - 10% (2027); 20% (2030) Spain - 13% (2025); 15% (2030) Mexico Japan
Reuse	Establish reusability loops for secondary (at least 10% reusability) and tertiary packaging (at least 40% reusability).	PPWR Secondary - 10% (2030); 25% (2040) Tertiary - 40% (2030); 70% (2040) Spain - 20% (2030); 30% (2035)
Recycle	Ensure all packaging is recyclable.	Spain Japan - 100% (2035)
Recover	At least 75% of packaging by weight of the material used in the packaging should be recyclable. At least 50% of plastic packaging must be recycled.	PPWD - 65% (2025); 70% (2030) Spain - Greater than 50% Sweden - Greater than 75% France - 65% (2025)
Recycled Content	Plastic packaging must contain at least 50% post-consumer recycled content. Rigid plastic packaging should comprise 25% post-consumer recycled material.	PPWR - 35% (2030); 65% (2040) Spain - 30% (2030) Sweden - 30% California - 25% [Rigid]

Packaging Sustainability Guidelines		
Category	***Suggestion (With the horizon of 2030)***	***Motivation***
		Canada - 50% (2030) France Germany Japan - Double levels of 2019 (2030)
Packaging Design Considerations	Packaging should be easily separable at the end of its life. Use mono materials instead of commingled plastics. Avoid hindering recyclability with the use of coatings or adhesives.	
Space Utilization	Secondary and tertiary packaging should not exceed 50% empty space compared to the full load capacity.	PPWR Secondary - 50% Tertiary - 50%
Material Preference	Favor recycled kraft material over virgin fiber material where possible.	

Below are the points the case company should consider while making the supplier guidelines aiming for 2030 targets. The definitions and supporting data for the below points are presented in Appendix II.

- **Refuse**: Eliminate the use of single-use plastics.
- **Redesign**: Whenever and wherever packaging does not meet the sustainability targets, it should be prioritized for the redesign.
- **Reduce**: Reduce packaging weight by 20% from the current packaging levels, without compromising the intended purpose of the packaging.
- **Reuse:** Reuse at least 10% of group packaging and 40% of transportation packaging by establishing required reusability loops.
- **Recycle:** All packaging should be recyclable.
- **Recover:** At least 75% of packaging by weight of the material used in the packaging should be recyclable (i.e. yield after recycling). At least 50% of plastic packaging must be recycled.

- **Recycled content:** Plastic packaging must contain at least 50% post-consumer recycled content. Suppliers should have this data certified by the external responsible authority and must provide the certificates upon request. Rigid plastic packaging should comprise 25% post-consumer recycled material and have a recycling rate of 45%.
- Packaging should be easily separable at the end of its life for easy handling and disposal. If using plastics, use mono materials instead of commingled plastics.
- Try not to use coatings or adhesives which may hinder recycling.
- Group packaging and transport packaging should not exceed 50% empty space compared to the full load possible.
- Wherever possible, opt for recycled kraft material over virgin fiber material.

Including these points in the packaging regulatory document will give Axis a competitive advantage over its competitors but needs careful change management (Ahmad et al., 2022). For the successful implementation, Axis first needs to communicate the anticipated changes to the supplier via a dedicated channel and talk about their ambitions. Even though targets are set for the year 2030, Axis can set some yearly targets and have some tollgates to check the progress. Another way is to incentivize the suppliers to adopt these changes. If Axis considers all these factors and successfully implements the said point in its regulation, it can be at the forefront of packaging sustainability in its market.

To make sure the above guideline will serve the test of time, an interview was conducted with two PRO alliances in Europe. These interviews draw some critical conclusions. First, there will be a shift in regulations from current regulations concerning more household waste to including industrial waste as well. This makes the move of creating forward-looking guidelines valid and timely. Second, there will be an increase in the use of post-consumer recycled material in plastics, but practitioners be afraid of low economies missing the targets. Third, practitioners are uncertain about various targets and restrictions set in PPWR, quoting them as ‘Very Ambitious!’, but also mentioning that it needs to be achieved anyhow, or at least try! This is also in line with setting ambitious targets for suppliers can be overwhelming at first but if addressed well, can be doable. Lastly, it was very prominent that EPR will be the way forward, as this part took more time from the interviews, and companies need to be aware and take responsibility for the things they are putting in the market.

6.4 Implementation and Implications

6.4.1 Implications for Axis

Axis has climbed the commitment pyramid as shown in Figure 6.5, to set their science-based targets and aim for a reduction of scope 1 and scope 2 GHG emissions by 42% by 2030 from 2022 as the base year. They also commit to reducing scope 3 emissions from purchased goods and services, upstream transportation and distribution, and use of sold products by 51.6% during the same period (Science-based targets, 2024).

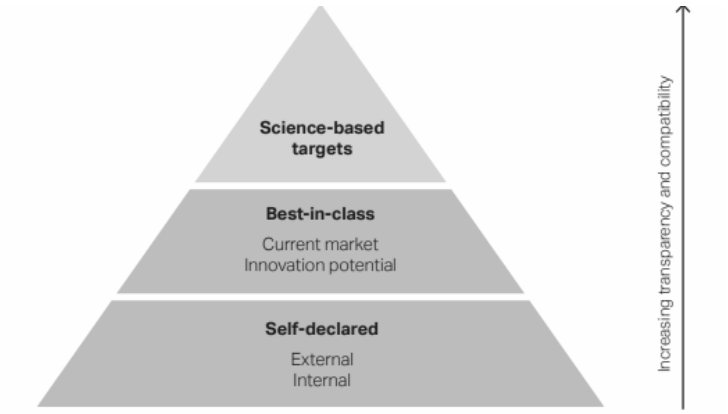

Figure 6.5: Commitment Hierarchy

Axis' approach to CE should include evaluating the long-term impacts and potential trade-offs associated with circular practices. Engagement with policymakers, investors, and industry leaders to shape favorable market conditions and regulatory environments. Collaboration across divisions and sectors can drive systemic change and support the transition to a circular economy (Eisenreich et al., 2022).

Axis, as an innovative company, should actively innovate in product design, material sourcing, and waste management to enhance circularity. This includes conducting thorough life cycle assessments and investing in research and development to identify and mitigate unforeseen consequences (Greer et al., 2021). Educating stakeholders about the complexities of material categorization and the benefits of a circular economy can drive more informed decision-making and greater support for circular initiatives.

A precondition of successful development of packaging is the consideration of the entire packaging supply chain (Varžinskas et al., 2016). It is a rather complicated

process because in each stage of the supply chain there might be different requirements and conditions that have to be combined. Strategic and tactical functions of packaging, logistics, the level of damage to packed products, graphic design, and printing technologies are detailed in the packaging chain. There are many players and connections in the packaging supply chain and the regulations for packaging and related information are not always clear, there are uncertainties. The entire packaging life cycle should be also considered in terms of the environmental impact of packaging.

To integrate these guidelines in the packaging systems, Axis would need to modify its packaging regulations document in the following ways. First, instead of allowing suppliers to choose the packaging, Axis should specify the types of packaging materials to be used in the supply chain. This is critical because, as discussed earlier, packaging changes form at every node in the supply chain, generating waste. If Axis defines the materials based on the recycling facilities at EMS locations, managing this waste would be easier.

Second, the control document should be as specific as possible when defining limits, numbers, and requirements, as this affects compliance, performance, and trust (Boussalis et al., 2016). Lastly, the control document should be created based on the regulatory framework and targets to achieve, creating positive pressure on suppliers to continually develop and update their practices over time (Sadiq & Governatori, 2015).

6.4.2 Packaging Development Process Revisited

The setup shown in Figure 6.6 creates a continuous process for packaging optimization. Each new packaging system or modification begins with accumulated knowledge and experiences from previous systems. This approach needs to be extended to supplier-designed packaging to create awareness regarding the potential benefits it can bring, in terms of reduction in overuse of packaging material, cost savings, and environmental sustainability.

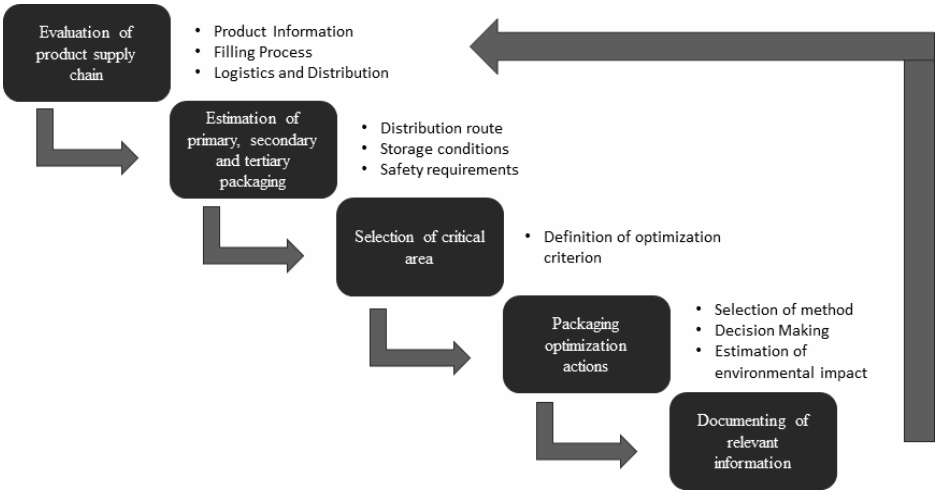

Figure 6.6: Packaging development process to accommodate packaging selection (Inspired by Varžinskas et al., 2016)

6.4.3 Barriers to Packaging Changes

Sluisveld & Worrel (2013) suggest there are several barriers to packaging modifications. With packaging optimization, a wide variety of demands, priorities, and uncertainties are incorporated into the decision-making process of the packaging industry. Implementing changes in an existing packaging line leads to high investment costs, requiring a long capital lifetime to become profitable, if even profitable for the initiator. A large fraction of packaging is determined by the price of (virgin) materials (e.g. 40–60% for plastic packaging), whereas materials under development (e.g. bioplastic) are more expensive.

Technical barriers can be found upstream and downstream in the supply chain. The upstream difficulty is the assumed practical limit for manufacturers; on the one hand, additional packaging material is inevitable, while on the other hand optimization opportunities are considered exhaustive. Downstream barriers include complications in packaging material recycling, limiting the quality and potential end-markets. A limited understanding of packaging specifications and a lack of communication through the supply chain create barriers to packaging optimization. Policy to stimulate prevention is not very detailed due to the wide range of requirements of packaging. Seeking compliance in various international legislations also creates complications. Standardization is suggested to bridge the various requirements across countries. Nahman's (2010) study reveals that industry

initiatives are more effective than government regulation in stimulating the recovery of packaging waste for recycling.

Waste prevention solutions may not necessarily benefit the environment in some cases and if packaging cannot fulfill its core function, like negatively influencing handling, high-speed filling, shelf-life, transport, and barrier properties, it may lead to wastage of the product and subsequently to increased environmental damage. Despite a perceived negative reputation of packaging waste in society, waste prevention remains an inferior concept for products in terms of hygiene and convenience.

6.4.4 Green Purchasing

Green purchasing can be effective in tackling environmental goals. Since purchasing is at the beginning of the supply chain, it becomes impossible to be successful without integrating the company's sustainability targets with purchasing activities (Min & Galle, 1997). Green packaging, in turn, cannot be successful without systematic reduction of upstream waste sources associated with purchased materials and their packaging. But this may lead to increased costs and quality suppliers may be limited.

6.4.5 Life cycle assessment

A Life-Cycle Assessment (LCA) could be used to assess the Design for the Environment of each packaging. The consideration of packaging materials' environmental impacts supported by an LCA analysis could be explored to help the design of environmental policies that would raise the use of more environmentally friendly packages (Rubio et al., 2018). There is a need to account for the whole life cycle of packaging, from design to production to transportation to consumption to recycling (Pires et al., 2015). A view only considering the packaging material recyclability is not the one to follow. As stated previously, package functionality may outweigh the impact that its treatment will have on the environment.

The end-of-life option for a product must be determined in the design stage (Muthu, 2015). Recovery and disposal are the options, but the basis of selection is based on environmental impact, legislation, quality, and cost.

Implementation of a CE affects nearly all of the company's value chain activities. The transition toward a CE creates cross-functional leadership responsibilities and

requires close collaboration with the external ecosystem (Eisenreich et al., 2022). Circular solutions often require major shifts in a company's business and operating model that lead to high levels of risk and uncertainty. CE research has revealed that the introduction of circular solutions strongly impacts organizational processes and strategic agendas.

Each member of the supply chain must collaborate and support each other to achieve the best environmental sustainability. Optimal packaging design reduces the excessive use of material and reduces environmental impacts right from source, manufacture, distribution, and delivery. The integration of sustainability concepts into legislation will change the environment in which firms work and the nature of competition. This calls for organizations to address new issues such as reverse supply chain (Eisenreich et al., 2022), responsibility for pollution, extent of recycling and reuse, and end-of-life product management.

7. Conclusion & Future Research

This chapter will summarize the findings and analysis of the research. The purpose will be revisited and how the research objectives were achieved will be answered. The limitations of the thesis explore potential areas for extending the research's scope.

7.1 Revisiting the purpose

The purpose of this master's thesis was to understand the objectives of the packaging regulations and transform this understanding into guidelines that can be further developed and implemented by the case company in their packaging decision-making. The purpose was addressed based on three research questions. First, a case study of the case company was conducted to understand the current packaging systems in place. Second, the current regulations being adopted, and the upcoming EU PPWR were reviewed to understand the direction in which these regulations are headed. Lastly, guidelines were proposed that could be used as a foundation by the case company to further develop their packaging sourcing requirements and inspire other companies in the same market.

RQ1: What are the packaging decision practices currently being employed at the case company?

The supply chain and packaging systems at Axis were identified and mapped. Through extensive data and information sharing, Axis exercises significant control over the flow of materials, ensuring smooth operations throughout the multi-tiered supply chain. The packaging decision-making process at Axis reveals that while there is some attention to sustainability, it is not deeply integrated into the packaging strategies, especially in the upstream. Suppliers are assessed on packaging criteria during selection, but the focus remains on basic compliance. Although packaging is categorized as non-critical when it comes to cost factors, it has strategic importance

in terms of maintaining product quality and reducing environmental impact. Axis has set ambitious targets for reducing emissions but achieving these targets requires a detailed packaging control document. By closer collaboration with suppliers and implementing solutions for packaging and material reuse, Axis can be proactive and be at the forefront of sustainability. It is critical for Axis to have cross-collaboration amongst environmental & sustainability, sourcing, and packaging teams to achieve the SBTs.

RQ2: What are the objectives and requirements of the packaging regulations implemented in the EU and other major economies, and how do they compare?

The global shift towards a circular economy is evident through various legislative efforts and strategic initiatives aimed at addressing the challenges posed by packaging waste. There is a shared vision between countries to transition towards a more sustainable economic model that focuses on resource efficiency, waste reduction, and the promotion of reuse and recycling. The EU is a lead advocate of a circular economy. Central to these efforts are regulations aimed at promoting the circularity of plastics, including design for recycling and minimum recycled content requirements. Source reduction emerges as a critical priority in waste management, with the EU setting ambitious packaging reduction targets for 2030 and beyond. Bans and restrictions on single-use plastics further underscore the commitment to reducing waste generation and promoting sustainable alternatives. EPR serves as a key policy tool to hold producers accountable for the lifecycle management of packaging materials. By imposing financial and operational responsibilities, EPR encourages producers to adopt sustainable practices and invest in recycling infrastructure.

RQ3: How can the case company integrate these regulatory requirements into its packaging decision-making process?

The analysis of packaging requirements across countries has provided valuable insights into the evolving landscape of sustainable packaging. By setting high targets based on the most stringent international standards, Axis can ensure compliance and drive environmental benefits. The proposed guidelines inspired by the 9R framework for circularity, with the view of implementation by 2030, form a base to address scope 3 emissions and enhance resource efficiency. Effective communication with suppliers, knowledge sharing, life cycle assessment, and incentivizing changes are crucial for successful adoption. The proactive approach will position Axis as a leader in packaging sustainability.

7.2 Implications of research

7.2.1 Theoretical Implications

The findings presented in this master's thesis are relevant for researchers. There is very little research conducted on understanding global packaging regulations. Since businesses nowadays operate on a global scale, it becomes necessary for them to comply with many legislative laws across various regions. Therefore, this area of research is quite important from an organizational perspective. However, having conducted a literature review, there is a gap that needs to be filled when it comes to understanding the different regulations and comparing them.

We have provided a foundation for developing guidelines that can be adapted by companies in their supply chain to address sustainability concerns and align with environmental targets. Currently, packaging requirements upstream in the supply chain are not considered a critical business decision, and supplier packaging guidelines are not standardized across the industry. We have highlighted the most discussed strategies which are the focus in different countries. The proposed guidelines are to be considered a base and need further detailed development to be executed.

7.2.2 Practical Implications

Managers at the case company, as well as those in similar contexts, could considerably benefit from the findings of this study. The study provides significant insights into a variety of national and legislative packaging rules that packaging managers may not normally evaluate. Packaging managers can use the study's recommendations to evaluate their existing control documents and, if necessary, create new ones.

The study emphasizes the need for collaboration across the sourcing, environmental, and packaging teams in helping organizations achieve their sustainability goals. Companies without a specialized packaging team can assign the proposals to their supplier managers, who can then use them to create standards for suppliers to improve package sustainability practices.

Environmental managers will find these proposals especially useful because they are based on legislation that directly addresses packaging-related concerns and waste. By implementing these guidelines, environmental managers can promote

awareness about packaging options inside their organizations, emphasizing the relevance of packaging sustainability in reaching overall sustainability goals.

7.3 Limitations and Future Research

7.3.1 Limitations

While this master's thesis provides insights, it is important to acknowledge its limitations. Firstly, the use of a single case study may limit the generalizability of the findings beyond the specific context investigated. The qualitative approach used for the study, while suitable for capturing data, is less suitable for rigorous validation. The lack of quantitative data poses a limitation. Its ability to quantify phenomena lends itself well to the validation process and more objective comparisons can be made, providing tangible and measurable evidence. Although the findings of this thesis are tailored to the systems of the case company, they offer valuable insights that can be extrapolated and adapted by other organizations. Furthermore, it is essential to note that while guidelines were developed based on the study's findings, the perspectives and feedback of suppliers regarding the proposed guidelines were not assessed.

Accessing and filtering through the various legislations was not very smooth. Each country had its way of representing these without any standardized platform, which made it difficult to find the relevant laws associated with the study. We have tried our best to identify and interpret them. Some laws were also in their regional languages and translation using *Google Translate* was a limitation. Furthermore, most laws and regulations were targeted towards household waste, which was a constraint as this thesis was more directed towards industrial packaging. Time constraints also impacted the depth of the study. The lack of literature made it challenging to make in-depth propositions. Instead, it dictated us to a more exploratory approach.

Another limitation noticed was that capturing data regarding packaging is difficult and the industry is lagging in this regard. The government may bring in effective policies and targets, but the businesses may fail to declare accurate data due to poor data capture mechanisms.

7.3.2 Future research

Packaging is a broad and strategic area often overlooked by companies (Koeijer et al., 2020). This thesis proposed guidelines for supplier packaging regulations, focusing primarily on environmental factors, and addressing Scope 3 emissions under SBTs. However, packaging has a wider scope that includes sourcing considerations as well. Future research should aim to combine environmental regulations with packaging and sourcing strategies to create more holistic and effective guidelines. This integrated approach will enhance the study of supplier guidelines and achieve a balanced intersection of sustainability and practical decision-making.

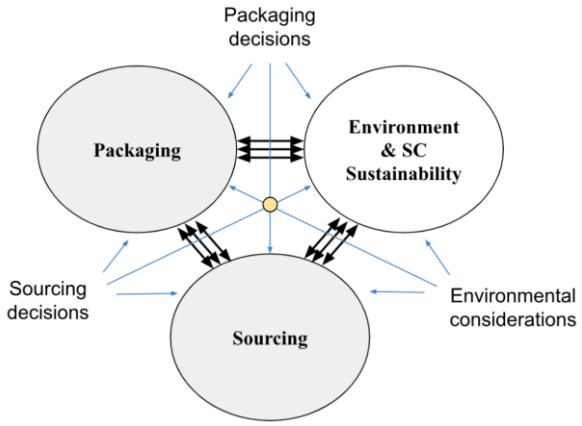

Figure 7.1: Future scope

Another effective way to continue this study is through the evaluation of the guidelines within actual settings. This would allow for an assessment of the trade-offs and impacts across the entire value chain. Additionally, conducting a feasibility study on collaboration with suppliers is crucial to gather their inputs and perspectives, which will enhance the effectiveness and acceptance of the proposed practices. This also presents an opportunity to study change management in this context.

A broader scope for future research includes a comparative study of packaging regulations among various companies, which could serve as a valuable benchmarking exercise for the case company. There is a notable lack of comparative studies analyzing packaging sustainability laws and regulations across different countries. Addressing this gap is important for fostering international collaboration and harmonizing practices. Furthermore, conducting quantitative validation studies could provide a robust analysis of packaging sustainability practices.

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Appendix A Interview guide

Semi-structured Interviews with internal employees

1) Industrial Lead team
2) Commodity team
3) Sustainability team
4) Packaging team
5) Sourcing team
6) Purchasing team

Interviewees were asked about their contact with packaging in their work area, and how do they perceive packaging sustainability in general. Also, how the implementation of guidelines would impact their work area and how it may affect the supplier relationship.

Structured Interviews with PRO Associations

1. Roles and activities conducted by your organization and how EPR monitors and ensures compliance and targets are being met.
2. Where does the organization see opportunities for enhancing packaging sustainability and circular economy compared to the previous directive?
3. Why do regulations focus their attention on household wastes and not industrial packaging wastes?
4. What is the industry's reaction to the latest draft of the PPWR regulations?
5. Are there any amendments within the upcoming PPWR that PROs have been actively advocating for?
6. What are some of the changes or revisions in the PPWR that PROs believe will be a challenge to EPR operations?
7. Expansion in the Americas and how does it compare to that of the EU?

Appendix B Guideline References

Major Laws

Country/ Region	***Law***
EU	PPWD – Directive 94/62/EC
France	Code de l'environnement Anti Waste Law
Spain	Royal Decree 1055/2022
Germany	Verpackungsgesetz Bundesgestezblatt
USA (California)	California Legislative
Canada	Canadian Environmental Protection Act, 1999