Circularity within MedTech: Key factors influencing the adoption of circular economy practices

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MASTER THESIS

Circularity within MedTech: Key factors influencing the adoption of circular economy practices

A review and multiple case studies of circular economy practices among Swedish MedTech companies

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Abstract

The healthcare sector, responsible for 5% of the world's carbon emissions, is at a critical juncture in adopting sustainable practices, particularly through the adoption of circular economy practices. This thesis examines the adaptation of circular economy practices by Swedish MedTech companies, aligning with the European Commission's Circular Economy Action Plan which supports the EU's climate neutrality goal by 2050.

This thesis explores the potential benefits and challenges associated with implementing circular business models within the MedTech industry. It aims to enhance understanding and interest in circularity while examining how companies can integrate environmental and economic sustainability into their business strategies.

The research questions are addressed through a comprehensive literature review and a multiple case study, which includes semi-structured interviews with nine Swedish MedTech companies. Insights from literature and interviews are synthesized to identify drivers and barriers, as well as key factors influencing circular business models. Additionally, the study explores circular business model innovation. Following this, a roadmap is developed that outlines practical steps for companies to innovate and adapt, ultimately facilitating integration of circular economy practices.

In conclusion, while the MedTech industry recognizes the substantial opportunities that circular economy practices offer for innovation and competitive advantage, numerous challenges could slow down this transformative shift. Significant barriers include stringent regulatory environments that limit flexibility in implementing circular economy practices, the high costs and investment risks associated with new business models, and the lack of infrastructure for circular processes.

Keywords: circular economy, circular business models, MedTech, HealthTech, drivers and barriers

Sammanfattning

Hälso- och sjukvårdssektor, som står för 5 % av världens koldioxidutsläpp, befinner sig vid en kritisk punkt när det gäller att anta hållbara metoder, särskilt genom införandet av praktiker för cirkulär ekonomi. Denna avhandling undersöker anpassningen av cirkulära praxis hos svenska MedTech företag, i linje med Europeiska kommissionens handlingsplan för cirkulär ekonomi som stöder EU:s mål om klimatneutralitet till 2050.

Den här forskningen utforskar de potentiella fördelarna och utmaningarna med att implementera cirkulära affärsmodeller i MedTech industrin. Den syftar till att öka förståelsen och intresset för cirkularitet samtidigt som den undersöker hur företag kan integrera miljömässig och ekonomisk hållbarhet i sina affärsstrategier.

Forskningsfrågorna behandlas genom en omfattande litteraturöversikt och en flerfallstudie, där semistrukturerade intervjuer genomförts med nio svenska MedTech-företag. Insikter från både litteraturen och intervjuerna kombineras för att identifiera drivkrafter och hinder, samt nyckelfaktorer som påverkar cirkulära affärsmodeller. Studien utforskar även hur innovation inom dessa affärsmodeller kan tillämpas. Utifrån dessa insikter utvecklas en färdplan som beskriver konkreta steg för företagen att innovera och anpassa sina verksamheter, vilket ultimativt underlättar integreringen av praktiker för cirkulär ekonomi.

Sammanfattningsvis indikerar resultaten att även om MedTech industrin känner igen de betydande möjligheter som antagandet av principer för cirkulär ekonomi erbjuder för innovation och konkurrensfördelar, kan många utmaningar bromsa transformationen. Betydande barriärer inkluderar strikta regleringar som begränsar flexibiliteten i att implementera cirkulära metoder, de höga kostnaderna och investeringsriskerna förknippade med nya affärsmodeller, samt bristen på infrastruktur för cirkulära processer.

Nyckelord: circular ekonomi, cirkulära affärsmodeller, MedTech, HealthTech, drivare och barriärer

Preface

The authors have completed this thesis as part of their master's program in Industrial Engineering and Management at the Faculty of Engineering, Lund University. Throughout their academic journey, they have been particularly drawn to the connection between sustainability and technology, ultimately fostering a profound interest in the application of circular economy principles within the MedTech industry. The decision to pursue this topic stemmed from a mutual curiosity about the ways in which MedTech companies are embracing circular economy strategies to advance sustainability and operational efficiency.

This research was carried out in collaboration with the Swedish MedTech platform, which facilitated access to numerous companies at the forefront of innovation. Conducted over a period of six months, the study involved comprehensive case studies and interviews with key representatives from these pioneering companies.

Special thanks are extended to all the professionals who agreed to participate in our research, sharing their valuable insights and experiences, which have greatly enriched this thesis. We are also grateful for the continuous support and expert guidance from our thesis advisor, Jessica Wadin, who provided essential feedback to successfully complete this project.

Lund, May 2024

Sara Berggren and Kajsa Högberg

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List of acronyms and abbreviations

AI	Artificial Intelligence
BM	Business Model
BMC	Business Model Canvas
BMI	Business Model Innovation
CBM	Circular Business Model
CBMI	Circular Business Model Innovation
CE	Circular Economy
CEAP	Circular Economy Action Plan
ESG	Economic, Sustainable and Governance
EMA	European Medicines Agency
FDA	Food and Drug Administration
IVD	In Vitro Diagnostics
MedTech	Medical Technology
MD	Medical Device
SBM	Sustainable Business Model
SBMI	Sustainable Business Model Innovation
SDG	Sustainable Development Goal
SME	Small and Medium Enterprises

1 Introduction

This chapter introduces the thesis by first outlining the background of the identified problem. Following this, the problem description, the purpose of the thesis, and the research questions are presented. The chapter concludes by clarifying the study's focus and delimitations and defining the target audience.

1.1 Background

The World Health Organization stated in its annual health statistics report (World Health Organization, 2023) that climate change is one of the greatest health challenges of the 21st century. Climate change and the extensive use of natural resources pose a global threat. This is evident in increasingly frequent and severe weather and climate events, including storms, extreme temperatures, floods, droughts, and wildfires. These events exert a harmful effect on public health, leading to an increase in health risks and underscoring the urgent need for sustainable interventions.

Within this broad environmental and health challenges context, the healthcare sector significantly contributes to global carbon emissions, accounting for 5% of the world's total carbon emissions (Boston Consulting Group, 2023). Medical technology (MedTech) companies, through the production and use of medical devices, innovation, and technologies, play a substantial role in this context (Boston Consulting Group, 2023; Kulkov, 2021; Makoliso et al., 2020; Mejtoft et al., 2022). In alignment with this, the European Commission introduced a new Circular Economy Action Plan (CEAP) at the beginning of March 2020 (European Commission, n.d.). This action plan supports the EU's agenda for sustainable growth, advocating for circular economy (CE) practices that enhance resource efficiency, reduce waste, and promote sustainable product design, with the aim of achieving climate neutrality by 2050.

CE practices involve strategies that "minimize waste and recapture resources in a closed-loop system" (Ronn et al., 2023, p. 2). These strategies are characterized by sustainable product design, efficient resource management, and waste reduction, playing a crucial role in driving the transformation towards circularity in the

MedTech industry and promoting environmental responsibility. Circular Business Models (CBM) are defined as business strategies that enable the implementation of CE practices (Schroeder et al., 2019). These models are designed to transform traditional, linear business operations into circular systems that emphasize and create value by regenerating the organizational system (Ronn et al., 2023; van Dolderen, 2023). While CE practices focus on the technical and operational adjustments needed to minimize waste and maximize resource use, CBMs embed these practices into the core business strategies and models. This relationship ensures that companies not only adopt sustainable practices but also adapt their business frameworks to support these practices long-term, ultimately contributing to a more sustainable global economy.

MedTech includes solutions, products, or services aimed at improving and promoting health and well-being (APACMed, n.d.; Mejtoft et al., 2022). The technology offers help to patients and the healthcare system by facilitating and improving the prevention, diagnosis, monitoring, treatment, and care of patients. Within this framework, MedTech companies serve as key stakeholders, driving the transformation towards circularity in their industry. By adopting CE practices and exploring CBMs, MedTech companies can significantly reduce their environmental impact while continuing to deliver high-quality healthcare (Ishaq et al., 2024). This approach not only contributes to environmental responsibility but also aligns with the broader Agenda 2030 and the United Nations global sustainability goals, aiming to achieve social, economic, and environmental sustainable development (MedTech Europe, 2022).

Studies have shown a strong correlation between the implementation of CE practices and the achievement of Sustainable Development Goals (SDG) (Awan and Sroufe, 2022; Benz, 2022; Brendzel-Skowera, 2021; Rosati et al., 2023; Schroeder et al., 2019; Valverde and Aviles-Palacios, 2021). The study by Valverde and Aviles-Palacios (2021) contributes to this discourse by showcasing how CE strategies directly target specific SDGs. The findings align with SDG 6 *Clean Water and Sanitation*, SDG 8 *Decent Work and Economic Growth*, SDG 12 *Responsible Consumption and Production*, and lastly, SDG 15 *Life On Land*. The shift towards a CE offers significant potential for substantial health gains and supports the achievement of various SDGs (Europe, 2018). These advantages manifest directly through cost reductions in healthcare and indirectly through the diminished environmental footprint associated with production and consumption processes within the MedTech industry.

Realizing the potential benefits of adopting circularity in the MedTech industry requires strong action from the private sector (Schroeder et al., 2019). The growing interest in CE practices and more sustainable business models reflects a significant shift towards sustainability, driving innovation within the MedTech industry (Ishaq et al., 2024; Marquet and Vetters, 2023; Pieroni et al., 2019). MedTech companies that explore CBMs and embrace CE practices can achieve greater cost efficiency and enhanced environmental sustainability. This thesis aims to study the potential

benefits and address the challenges of adopting CBMs targeting the MedTech industry. It will do so by examining Swedish-founded MedTech companies.

1.2 Problem description

The MedTech industry plays a crucial role in improving and promoting health and well-being. The industry has also emerged as a key player with a substantial environmental footprint (Boston Consulting Group, 2023; Ishaq et al., 2024; Kent, 2021; Schroeder et al., 2019) Particularly, during the COVID-19 pandemic, the management of medical waste saw a marked increase in the use of single-use disposable devices (Chen, 2021). The primary disposal methods for these devices are incineration and landfilling, which, while effective in reducing the volume of waste, are not sustainable (Chen, 2021; Ishaq, 2024). These methods lead to significant environmental pollution, including emissions of toxic gases and long-term soil and water contamination (Chen, 2021). Additionally, the MedTech industry's focus on selling new medical devices rather than extending the lifespan of existing ones generates significant packaging waste (Ishaq, 2024). Consequently, the industry is at a critical juncture where integrating sustainable CE practices is essential for upholding economic and environmental responsibilities. However, the journey towards sustainability is fraught with challenges, including the need to innovate in product design, manufacturing processes, and business models that align with CE principles.

Despite the growing interest among MedTech companies in adopting more sustainable, circular approaches, existing research primarily focuses on sustainable development and CE practices within the broader healthcare industry. Although MedTech falls under the healthcare sector, more in-depth research is essential to tailor these practices specifically for MedTech applications. Accordingly, few research studies have been conducted in the field that include both MedTech and circularity. As a result, the authors noticed that there is a lack of a comprehensive understanding of how the MedTech industry can develop and adopt CE practices. This gap emphasizes the need for guidelines to support MedTech companies' transition towards circularity. Addressing this gap through research could also support the broader objectives of sustainable development by enabling MedTech firms to continue delivering high- quality healthcare solutions.

1.3 Purpose and research questions

The primary purpose of this study is to increase interest and knowledge of circularity within the MedTech industry, seeking to create discussion among MedTech

companies. Additionally, the study aims to support Swedish MedTech companies in integrating environmental and economic sustainability into their business models by adopting CE practices. This involves examining how these companies navigate the complexities of implementing CBMs, identifying key barriers and drivers to adoption, and mapping out key factors that need consideration. To systematically address these objectives, the study has developed three research questions, which are detailed in Table 1.1. These questions are designed to explore the practical aspects of circularity adoption, offering insights and guidance to MedTech companies on how to successfully integrate these practices into their business strategies.

Table 1.1 Research questions.

RQ1	What are the key drivers and barriers within the MedTech industry that influence the adoption of circular economy practices?
RQ2	What key factors influence the successful adoption of circular business models in MedTech companies?
RQ3	What key factors influence the adoption of circular business model innovation? How do MedTech companies employ circular business model innovation?

Research questions 1-3a will be addressed by conducting a thorough review of existing literature in the field and by conducting a case study with MedTech companies. Research question 3b will mainly be answered through the case study. This dual approach will enable deeper insights into theoretical foundations and practical applications. Based on the findings from the literature review and case study, a roadmap will be developed to guide MedTech companies in adopting CE practices and CBMs, outlining strategic directions for their business development.

1.4 Focus and delimitations

In this qualitative study, the primary focus is on understanding how Swedish MedTech companies integrate CE practices within their business models. Given the complexity and breadth of the MedTech industry, the research is delimited to companies based in the Stockholm and Skåne regions, representing a specific segment of the European and American markets where these firms are active.

Due to the scope of this research, the analysis is restricted to environmental and economic dimensions of sustainability. Additionally, the study examines only companies that fulfill two predetermined criteria detailed in Section 2.5.

This focus allows for a detailed exploration within a manageable framework but also limits the generalizability of the findings to other geographical areas or segments of the MedTech industry not covered by this study.

1.5 Target audience

This study is primarily directed toward companies operating in the MedTech industry and holds extra relevance for the participating MedTech companies. Additionally, the study is relevant to academics and university students interested in the topic.

1.6 Thesis outline

This thesis includes eight chapters as outlined in Table 1.2 below.

Table 1.2 Thesis outline and summary of each chapter.

		Specificities
1.	***Introduction***	This chapter introduces the thesis by first outlining the background of the identified problem. Following this, the problem description, the purpose of the thesis, and the research questions are presented. The chapter concludes by clarifying the study's focus and delimitations and defining the target audience.
2.	***Method***	This chapter outlines the methodological framework for the thesis. It explains the chosen research strategy and the design of the study, along with the research method and approach. The chapter concludes with a discussion of the research's quality and ethical considerations for ensuring its validity and reliability.
3.	***The MedTech industry***	This chapter introduces the MedTech industry, outlining its key regulations, market dynamics, and prospects. Its purpose is to provide a broad overview of the industry and establish a thorough understanding of the context of the problem description.
4.	***Theoretical background***	This chapter provides a theoretical background on circular economy (CE) and outlines its practical implications for MedTech companies. It sets the stage for interpreting the empirical data and understanding the shift towards circularity in the industry.
5.	***Literature review findings***	This chapter presents the findings from the literature review, which addressed the research questions. The insights gathered from this review offer essential context and set the stage for the case study findings presented in Chapter 6.
6.	***Case study findings***	This chapter presents the findings from the interviews conducted with the selected case companies. The findings have been transcribed and compiled using the Gioia methodology.
7.	***Discussion***	This chapter presents a gap analysis, followed by a discussion of the key findings that contrast these findings with those from the literature review and the case study. Subsequently, interpretations are made, leading to a roadmap for future research. The chapter concludes by discussing research limitations.

8. Conclusion	This chapter presents the study's conclusions, directly addressing the research questions that guided the study and briefly introducing the roadmap. Following the conclusions, the implications for future research are discussed, highlighting potential areas for further investigation and development.

2 Method

This chapter outlines the methodological framework for the thesis. It explains the chosen research strategy and the design of the study, along with the research method and approach. The chapter concludes with a discussion of the research's quality and ethical considerations for ensuring its validity and reliability.

2.1 Research strategy

The research strategy outlines the detailed planning process for selecting appropriate research methods and approaches (Greener, n.d.). The planning process is vital for effectively addressing the questions posed by the research. The strategy of this thesis was inspired by the principles and structure of the research design described by Yin (2018) in Case Study Research and Applications. A well-defined research strategy is essential for effective research and information seeking (Yin, 2018). Central to this study is employing an interpretive research approach combined with a multiple-case study design. This approach facilitates a comprehensive understanding of the problem description and examines the stated purpose and research questions, which are found in Table 1.1. Utilizing qualitative research methodology, the empirical data relevant to the study was gathered through interviews with nine MedTech companies. This design ensures that the collected data aligns with the posed research questions and leads to conclusions that directly address the study's objectives.

2.2 Research design

After identifying the problem description and research questions, the design of the research strategy and method process was outlined. Yin's (2018) research design consists of six steps: plan, design, prepare, collect, analyze, and share. These steps were reconfigured to align with the research's objectives and were iteratively implemented. An overview of the research strategy is illustrated in Figure 2.1, with detailed explanations of each step provided in the sections below.

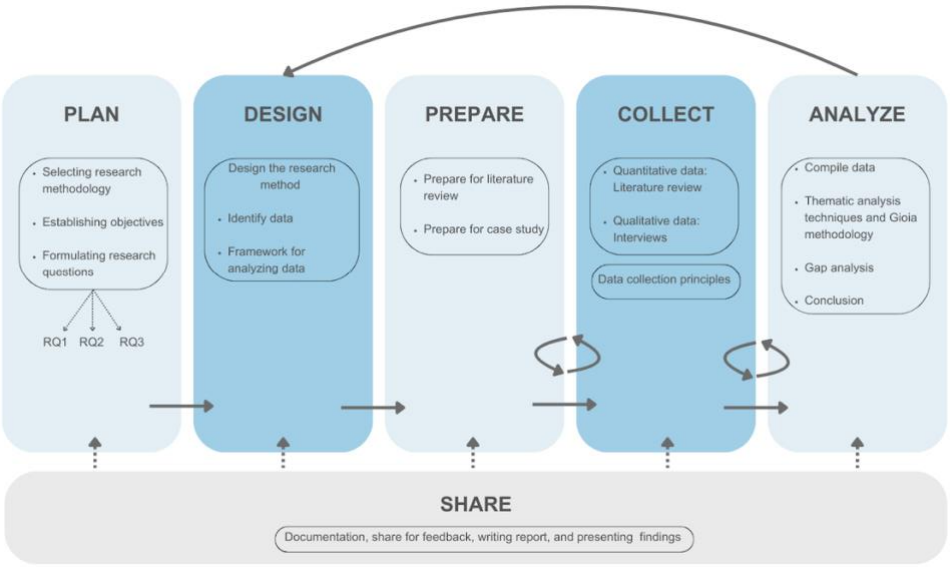

Figure 2.1 The research design strategy, inspired by Yin (2018).

2.2.1 Plan

The initial phase – *plan* – represents the foundational step in the research design strategy (Yin, 2018). It involves selecting the appropriate research methodology, establishing clear objectives, and formulating specific research questions to be addressed.

This thesis is conducted within the Department of Design Sciences at Lunds Faculty of Engineering, focusing on Innovation Engineering. With a specialization in business and innovation, the authors have recognized the growing importance of sustainability in the business sector and integrated this theme into the research topic. Further investigation revealed a notable interest in circular business models within the MedTech industry. To confirm this interest, emails were sent to 60 MedTech companies across Sweden, inquiring about their enthusiasm for exploring the implementation of circular business models and their willingness to contribute to research. The response was positive, with numerous companies eager to participate in this research. Consequently, the thesis direction was established, centering on the integration of circularity within business models in the MedTech industry. Subsequently, three research questions were formulated and served as a guideline.

2.2.2 Design

In the second phase – *design* – Yin (2018) introduces five components that shape

the research. Applying these components ensures a comprehensive understanding and interpretation of the findings within the specific context of the case study research. These components include the research questions, the propositions it posits, the cases under examination, the logic connecting the data to these propositions, and the criteria used to interpret the results. The first three components identify the data necessary to address the research questions. Stemming from these research questions, the authors decided to conduct a literature review and a case study as the basis for data collection (Höst et al, 2016; Yin, 2018). The latter two components provide a framework for analyzing this data. However, the frameworks in this study were selected post-data collection to best align with the objectives. This is further presented in Section 2.2.5 below.

2.2.3 Prepare

In the third phase – *prepare* – Yin (2018) emphasizes the importance of thoroughly considering all necessary steps before initiating data collection. A critical part of this phase involved comprehensively understanding the theoretical background and the specific issue being studied. This was achieved through a detailed review of previous literature from academic databases, such as Web of Science and Scopus, using various keywords to guide the search. The key findings from this process were then summarized and presented in the theoretical background, detailed in Chapter 4. A crucial element of the preparatory work involved setting standards for the literature review (Geissdoerfer et al., 2018). According to Höst, Regnell & Runeson (2016), conducting a comprehensive literature review is critical to a well-prepared scientific methodology. The strategies for planning and executing the literature review are further described in Section 2.4. Another part of the preparation work included conducting basic research about the case companies and preparing for the interviews. Further information about the planning and execution of the case study is described in Section 2.5.

2.2.4 Collect

In the fourth phase – *collect* – Yin (2018) introduces the key principles and practices of data collection that define this stage of the research design. In research, various common sources of evidence are used. Documentation and interviews have been the primary sources of evidence for this study. Documentation ranged from formal reports to emails and informal notes, providing diverse data. Additionally, a comprehensive literature review provided secondary data. Semi-structured interviews with selected case companies served as direct, insightful evidence.

In terms of data collection principles, Yin (2018) outlines four main principles designed to address potential challenges encountered during the data collection process, thereby ensuring the validity and reliability of the research findings. These

principles have been consistently applied in this research to ensure reliability and validity and are illustrated in Figure 2.2.

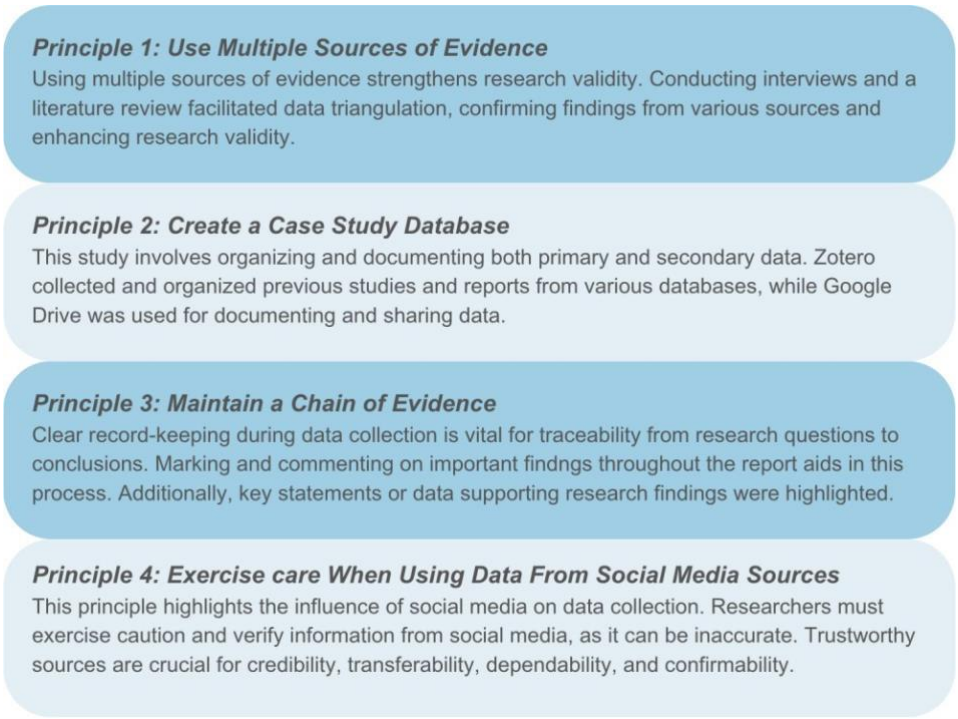

Figure 2.2 Data collection principles for this thesis, inspired by Yin (2018).

2.2.5 Analyze

In the fifth phase – *analyze* – the critical importance of having a strategic approach to analyze collected data is emphasized (Yin, 2018). The analysis took two distinct parts, which involved summarizing and analyzing the data and comparing and examining the similarities and differences between theory and practice. This thesis employs a mixed-method approach, integrating qualitative analysis techniques. The data analysis process is illustrated in Figure 2.3.

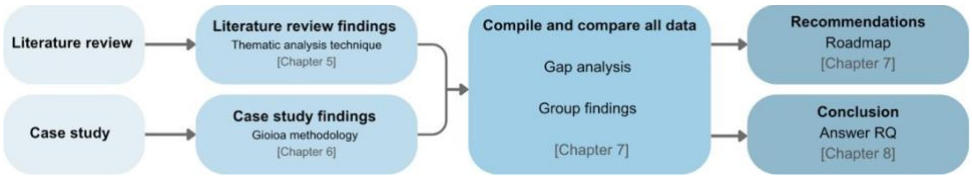

Figure 2.3 Overview of the analysis method.

After collecting the qualitative data, the findings were further highlighted, compiled,

and summarized using different analysis techniques to find various patterns in the data.

Literature review findings

The findings from the literature review were organized using thematic analysis techniques as described by Ryan and Bernard (2003). This approach proved instrumental in identifying, analyzing, and reporting themes within the data. Initially, the analysis involved observing repetitions, similarities, and differences across the literature to highlight recurring barriers, drivers, and key factors influencing the adoption and implementation of circular business models. This technique facilitated a methodical organization and interpretation of the extensive data collected, enabling a more structured understanding of the landscape within the literature.

Case study findings

The adoption of the qualitative research approach, through a multiple case study design, directed the gathering of primary data. Following the conduction of semi-structured interviews, the data were transcribed and analyzed using the Gioia methodology (Gioia et al., 2013). This methodology is designed to systematically guide the process of organizing, analyzing, and presenting data received from qualitative research. For this research four different Gioias analysis were made, each addressing different parts of the research questions. This was primarily to get a better overview of the different research areas. The methodology's structure begins with first-order concepts, where the data is directly collected from the participant responses. The responses are somewhat grouped into different themes depending on what area and research question they address. Next, these concepts are summarized into second order themes by further grouping the statements into similar areas. Finally, these themes were aggregated into broader dimensions, encapsulating the study's primary conceptual contributions. These dimensions were inspired from the areas that were found in the literature review. This structured approach ensures a comprehensive and systematic analysis of the qualitative data.

Analytical techniques

After selecting the analytical approach, Yin (2018) outlines techniques for advancing the case study analysis. Within this thesis, the technique of pattern matching was specifically employed. This method involves comparing two sets of patterns, the expected patterns that are empirically based (from secondary data) and the observed patterns collected from interviews (from primary data), to determine whether they match. A triangulation method was implemented to validate these findings. This involved verifying the pattern-matching results by cross-checking them with data from the literature review and interview findings. This critical step enhances the reliability of the results by ensuring consistency across different data sources. The findings were further organized and presented according to the

commonly identified themes, which were then used for the final recommendations and conclusions. The recommendations, outlined as a roadmap, were presented to guide MedTech companies in adopting CE practices, aiming to facilitate their transition towards circular business models. The conclusion finally highlights the key findings and recommendations for future research.

2.2.6 Share

In the final phase of the research design process - *share* - the guidelines for structuring and detailing a case study presentation are discussed (Yin, 2018). Throughout the project, note-taking has been consistently employed to monitor progress and provide valuable support to the final stages of the report. Draft versions of the report were regularly shared with the supervisor to gather feedback and gain external insights. Upon multiple critical reviews, the report was finalized, and preparations were made for the concluding presentation. This final presentation took place at Lund University, where the research outcomes and findings were shared with the examiner and subjected to opposition. Additionally, the report was sent to the case companies involved in the study.

2.3 Research method and approach

Höst et al. (2006) highlight that the choice of methodology depends on the research's objectives and nature. Yin (2018) further elaborates that each research method serves three purposes. Exploratory research delves deeper into understanding the "how" aspects, offering a more in-depth investigation into the workings of a topic (Höst et al., 2006; Yin, 2018), while problem-solving research is focused on finding solutions to identified problems. This thesis utilizes a combination of exploratory and problem-solving approaches adapted to align with the problem definition and the research questions outlined in Table 1.1. Yin (2018) also categorizes primary methods, each uniquely suited to different research objectives. For the objective stated in this thesis, the research questions suggest conducting an exploratory case study.

2.4 Literature review

A literature review aims to search for relevant sources to find existing knowledge that can be used while minimizing the risk of overlooking past lessons (Höst et al., 2006). Compiling sources and information systematically is beneficial to gain a comprehensive understanding of the theory and research topic. The literature review

contributes to theory and will also be used in the analysis when comparing theory with practice. The method for the literature review was inspired by Geissdoerfer, Vladimirova & Evans (2018) research methodology. The overview of the literature review process can be seen in Figure 2.4

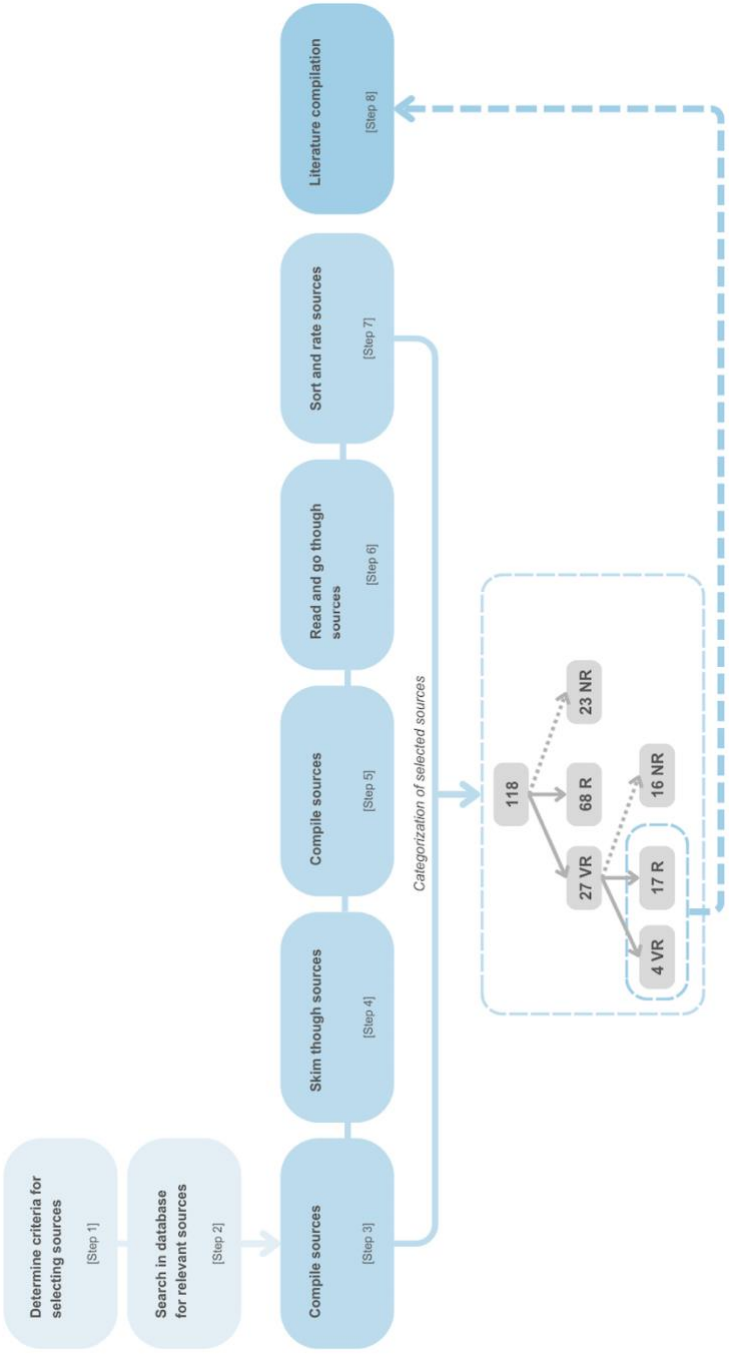

Figure 2.4 Visualization of the literature review flowchart, inspired by (Geissdoerfer et al., 2018).

Step 1: Determine criteria for selecting sources

In the first step of the literature review, the criteria for sorting and selecting sources were determined (Höst et al., 2006). Evaluating the reliability of sources is fundamental. Thus, a critical approach toward sources and prioritizing research from credible sources is imperative. The literature review is limited by using the databases Web of Science and Scopus. Additionally, the selection of sources was restricted to those published from 2015 onwards since this was when journal articles and reviews on CBMs began to increase (Geissdoerfer et al., 2018).

Step 2: Search in the database for relevant sources

Before searching for relevant sources, a set of keywords was constructed. The keywords were circular economy, circular business model, sustainable business model, business model innovation, MedTech, HealthTech, barriers, and drivers. In some cases, synonyms for "barriers" and "drivers" were used instead to increase the search results. The keywords were combined in different constellations to maximize the output of relevant sources. The search strategy adhered to the guidelines of initially searching broadly, selecting relevant findings, and searching deeply (Höst et al., 2006).

Step 3: Compile sources

After searching the databases, 118 papers and sources were found using the keywords. These sources were later compiled in a Google Sheets document. The first compilation contained the source's author, title, year of publication, and abstract.

Step 4: Skim through sources

After compiling the sources, the abstracts of each source were thoroughly reviewed. Each source was evaluated for its relevance and potential contribution to the research. The rating system followed the grades: Very Relevant (VR), Relevant (R), or Not Relevant (NR).

Step 5: Compile sources

Upon reviewing the 118 sources, 27 were categorized as Very Relevant (VR) and 68 as Relevant (R). The sources classified as VR offered particularly relevant insights on MedTech, CBMs, and/or business model innovation. These VR and R sources were separately compiled into new spreadsheets for further evaluation.

Step 6: Read and go through the sources

To deepen the understanding of the 27 selected articles, significant emphasis was placed on examining sections detailing objectives and outcomes. Summaries and key insights were noted in the existing spreadsheet. Subsequently, backward and forward snowballing sampling was continuously performed while reading the articles (Wohlin, 2014).

Step 7: Sort and rate sources

After reading through the articles that had been selected in step 5, the sources were further sorted and rated according to the rating system that was previously mentioned. This time, the rating was based on to what extent the articles fulfilled the following criteria:

- Circular business models and/or MedTech are explicitly addressed in the study.
- Includes some important contributions to this research.

These sources were again scored according to the VR, R, and NR grading systems. Based on the criteria, four sources were graded VR, and 17 were graded R. Further, these sources were again compiled in the next and last step of the review.

Step 8: Literature compilation

In the final step of the literature review, the sources were summarized and compiled one last time. The compilation was based on the rating from step 7. The four VR sources were first compiled and summarized in a separate document. These sources were read more carefully since they contained valuable facts and insights that can be useful in the work and further analysis. The same was done with the 17 R sources. These summaries created the foundation for the analysis. An overview of the 21 main selected sources, including a summary, can be found in Appendix A.1.

2.5 Case study

A case study is a detailed empirical investigation into a contemporary phenomenon within its natural setting (Yin, 2018). This method is valuable when understanding and examining a specific case with a specific aim, as it offers an in-depth focus on a case to maintain a holistic perspective (Höst et al., 2006; Yin, 2018). The case study procedure will adhere to a specific design inspired by Yin (2018).

2.5.1 Case study design

Case studies include single- and multiple-case designs (Yin, 2018). As illustrated in Figure 2.5, the procedure chosen for this case study follows a multiple-case study design to explore the research issue. Multiple-case studies are more robust than single-case studies as they provide stronger, more compelling evidence (Yin, 2018). The design for conducting a multiple-case study employs an analogous logic, where each case is carefully selected to ensure that the findings offer both literal and theoretical replications. To this end, specific criteria were applied when selecting case companies.

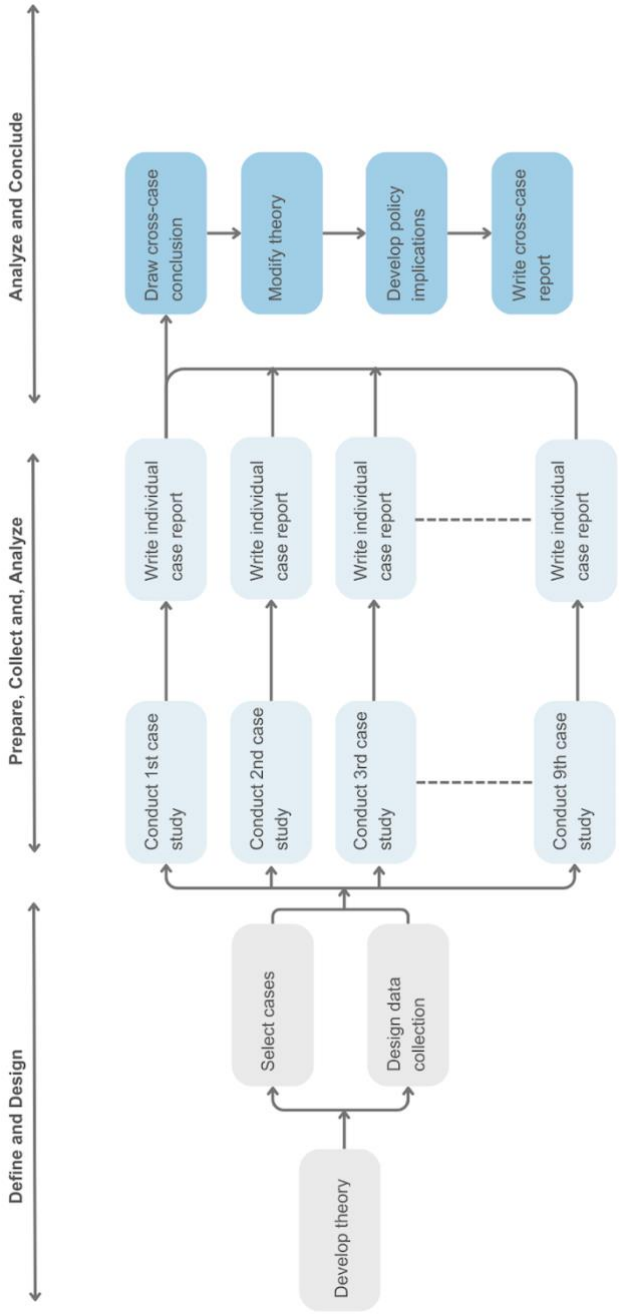

Figure 2.5 Illustration of the Multiple-Case Study Procedure inspired by Yin (2018).

2.5.2 Case study selection

Yin (2018) suggests conducting 6-10 case studies is preferable. For this multiple-case study, the authors contacted 60 companies, aiming to conduct at least six interviews. Nine of these companies responded and agreed to participate. The interviewees from these companies, including CEOs, CTOs, or COOs, were chosen due to their significant influence and in-depth knowledge regarding their company's business models, development, and management strategies. All nine interviews were recorded and transcribed, either during or immediately after completion. Further details of the interviews can be seen in Appendix B.1.

The selection of case companies was guided by their adherence to specific criteria required for participating in this study. These criteria were set to ensure that the selected companies were not only relevant to the MedTech industry, reflecting its innovative landscape, but also of relevance to the objectives of this research. The MedTech industry is used to denote the sector focused on the "application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures, and systems developed to solve a health problem and improve the quality of life" (van Dolderen, 2023, p. 5). The predetermined criteria are as follows:

- The company must operate within the MedTech industry, indicating a focus on the MedTech industry.
- The company must be engaged in the development of innovative MedTech products or possess patented innovation in the MedTech industry, highlighting its contribution to MedTech.

2.5.3 Case companies

Nine MedTech companies (MC1-MC9) were studied to address the purpose and the posed research questions. These companies were founded in Sweden and operate within the EU and/or the US. Regulations for MedTech companies differ between the EU and US markets, depending on the category and classification of the company's product or service. Table 2.1 provides an overview of the participating case companies.

Table 2.1 Overview of the case companies.

Case Company	*Headquarters*	*Years of experience*	*Operating in*	*Category and classification*	*Product or service development cycle*
MC1	Lund, Medicon Village	8 years	US EU	FDA: IVD, Class II EMA: IVD, Class C	Ongoing clinical validation ahead of launch in 2025
MC2	Stockholm, Sweden	9 years	EU	MD, Class IIa	Last clinical trial before applying for CE-mark
MC3	Stockholm, Sweden	4 years	US EU	Digital health solutions	Development phase
MC4	Lund, Medicon Village	11 years	US EU	FDA: MD, Class II EMA: MD, Class IIa	Design freeze ahead of launch in 2025
MC5	Lund, Medicon Village	18 years	US	MD, Class III	Development phase
MC6	Lund, Medicon Village	6 years	EU US	FDA: MD, Class II EMA: MD IIa, Suture: III	Clinical trial for CE and FDA approval
MC7 a	Lund, Sweden	11 years	US EU	-	Scale up phase
MC8	Lund, Sweden	25 years	US EU	EMA: MD, Class I FDA: MD, Class I	Driving growth
MC9	Stockholm, Sweden	24 years	US EU	FDA: MD, Class II EMA: MD, Class IIb	Early maturing phase

a MedTech building system, does not fall under the medical device regulations and therefore has no classification.

2.5.4 Interviews

The interviews followed a semi-structured format based on an interview which can be seen in Appendix B.2. The semi-structured format allows the interviewer to ask relevant follow-up questions and adapt the conversation according to the respondent (Greener, n.d.). Moreover, open-ended questions facilitated the interviewees' ability to elaborate on their thoughts, encouraging discussion (Höst et al., 2006). A PowerPoint presentation was displayed during the interviews to ensure a shared understanding and consistent use of terminology, as detailed in Appendix B.3.

Collecting case study evidence requires detailed planning preparations (Yin, 2018). In the process of conducting interviews, several important aspects were included to ensure that the results would be both reliable and validated. A comprehensive literature review was conducted in advance to identify the most relevant and well-formulated questions, as well as to ensure active participation and adaptability. The most critical questions and topics were highlighted in the interview guide, serving

as a cornerstone for time management and strategic planning.

To ensure ethical considerations, the interviewees were informed about the recording process and asked for their consent. Subsequently, the recording was transcribed for analysis purposes. Moreover, the interviewees were informed of the scope of the thesis and the intended use of their contributions. Emphasizing that the report would be a public document, their informed consent was obtained for participating in the research.

2.6 Quality of research

According to Lincoln and Guba's (1985) theory, there are four criteria for assessing the quality of qualitative research. Credibility, transferability, dependability, and confirmability are fundamental terms that ensure and demonstrate the quality of the study. The terms entail:

Credibility corresponds to internal validity and refers to the trustworthiness of the sources. Triangulation is a common technique to achieve credibility (Lincoln and Guba, 1985; Yin, 2018).

Transferability corresponds to internal validity and the extent to which the study results can be generalized (Lincoln and Guba, 1985). It encourages researchers to provide detailed descriptions of the research context and participants so that other researchers can assess the applicability of the results to different contexts.

Dependability corresponds to reliability in quantitative research and focuses on the stability of the study over time. To ensure dependability, researchers may conduct an audit trail. This approach involves detailed documentation of the research process, decisions, and adjustments made throughout the study. Such documentation facilitates literal and theoretical replication, enhancing the transparency of the research method.

Confirmability is a criterion for assessing the quality of qualitative research, corresponding to the principle of objectivity in qualitative research (Lincoln and Guba, 1985; Yin, 2018). Yin (2018) explores the critical importance of conducting unbiased research, emphasizing the importance of challenging findings with opposing evidence. Yin (2018) suggests that researchers should be able to assess their openness to unexpected and conflicting results from the beginning of the data collection. This process involves sharing research findings and engaging in regular discussions. This iterative feedback and revision process underscores the critical role of ethics in ensuring the integrity and objectivity of research endeavors and, therefore, minimizes the potential for bias.

2.6.1 Research ethics

Ethical considerations are fundamental in guiding moral choices that influence decisions, standards, and behaviors, particularly in research (Greener, n.d.). This encompasses the practicalities of conducting a study, such as coordinating interviews, selecting data samples, addressing participants' change of mind about their involvement, or managing the discovery of sensitive information. Ensuring that data collection and documentation methodologies are purposefully designed, systematic, and comprehensive is crucial. When employing a semi-structured interview approach, it is critical to consider the recording systems utilized.

2.6.2 Artificial Intelligence

Artificial Intelligence, AI, has emerged as a phenomenon and technology increasingly commonly used, serving as a tool for synthesizing and analyzing information. Hence, the capabilities of AI have been leveraged to ensure transparency and efficiency in the methodology. Specifically, the AI tool ChatGPT was employed to edit and streamline the data management of this report. This utilization of AI significantly facilitated the efficiency in reviewing and summarizing articles in the literature review, thereby enhancing the overall efficiency of the analysis. Grammarly, an AI writing assistant, was also used to improve the text and its readability by checking spelling and grammar.

3 The MedTech industry

This chapter introduces the MedTech industry, outlining its key regulations, market dynamics, and prospects. Its purpose is to provide a broad overview of the industry and establish a thorough understanding of the context of the problem description.

3.1 MedTech: Pioneering in Healthcare and innovation

The medical technology industry, also called the MedTech industry, encompasses a broad range of solutions, products, and services designed to improve and support health and well-being (Kulkov, 2021; MedTech Europe, n.d.). The definition underscores the primary objective of MedTech as "the technologies that diagnose, treat and/or improve a person's health and wellbeing, encompassing both low- and high-risk medical devices" (APACMed, n.d.). MedTech plays a pivotal role in supporting both patients and the healthcare infrastructure by providing solutions that improve the quality of medical care and reduce the time and financial cost of treatment, prevention, diagnosis, monitoring, and ongoing care (Kulkov, 2021; MedTech Europe, n.d.).

As the MedTech industry continually evolves and nurtures innovation, significant investments are made in R&D resources and financial support. This positioned the MedTech sector in 2022 as the second largest industry in terms of patent applications within the EU, representing 8,1% of all applications (MedTech Europe, 2022). Innovations in healthcare are crucial for driving advancements in critical areas such as disease diagnosis and treatment, clinical research, and medical imaging, among others (IBM, n.d.). These technological breakthroughs are pivotal in enhancing patient care and health outcomes. It is, however, essential to distinguish MedTech from HealthTech. The World Health Organization defines HealthTech in terms similar yet distinct from MedTech as "the application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures, and systems development to solve a health problem and improve quality of life" (European Medicines Agency, n.d.; van Dolderen, 2023). The healthcare sector has a global drive to grasp the MedTech innovation comprehensively (Gonzalez-Moral et al., 2023). This focus aims to ensure system readiness and the fast-tracking of technological solutions in areas with unaddressed needs, ultimately contributing to the overarching goal of elevating global health standards and

accessibility. Figure 3.1 illustrates that HealthTech and MedTech are complementary sectors that collaborate and hold the potential to advance the healthcare sector through their synergies. HealthTech solutions contribute valuable insights and data to MedTech devices, which not only bridge the gap between technology and medicine but also streamline processes, improving the future within healthcare (JioHealthHub, 2023; Konstantakopoulos, J., 2021).

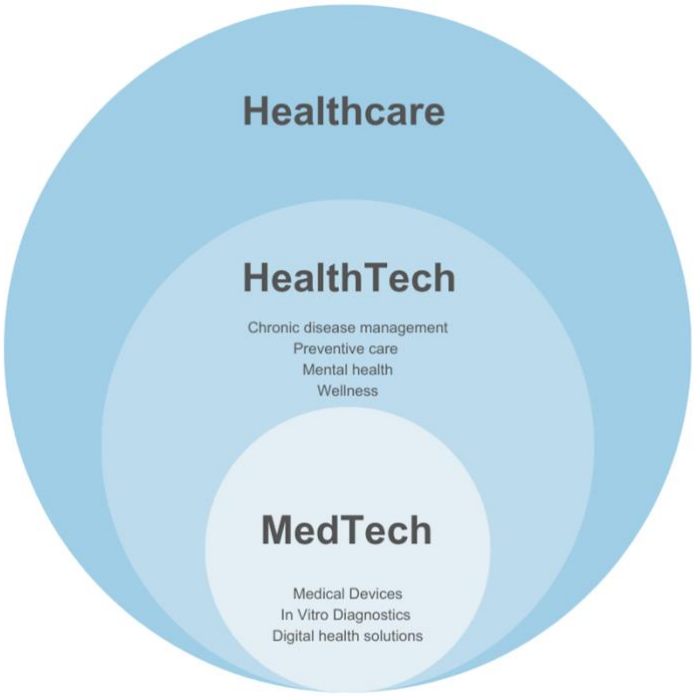

Figure 3.1 An overview of synergies and collaborations between HealthTech and MedTech across healthcare.

3.2 Regulations

Innovations in HealthTech directly interact with humans, necessitating stringent regulations to ensure safety (McDermott et al., 2022). The medical device (MD) sector is among the most regulated globally due to the associated risks. These regulations are designed to protect the safety of patients and users by setting standards and requirements that MDs must fulfill to achieve market approval (McDermott et al., 2022; Mejtoft et al., 2022). This regulatory framework encompasses various provisions, including product development, clinical trials, manufacturing, labeling, marketing, and post-market surveillance (Kang et al., 2023).

This study specifically focuses on companies established in Sweden that maintain their offices within the country and extend their operational reach to the EU and the US. Regulations for governing MedTech in these regions are instituted by regulatory authorities at both national and international levels, which support and foster a globalized approach to development (Thor et al., 2023). The variation in regulations across different geographic markets is significant, with distinct directives highlighting differences between the EU and the US, which are crucial for developing market entry strategies as they provide guidelines for scientific, technical, and clinical data (Letourneur et al., 2021).

In Europe, the European Medicines Agency (EMA) oversees regulations, playing a pivotal role in assessing medical products for the EU market (European Medicines Agency, n.d.; Mejtoft et al., 2022). The EMA evaluates marketing authorization applications for medicinal products through a centralized procedure, which considers the products' quality, safety, and efficacy. This process also extends to assessing the safety and performance of MDs when used alongside medicinal products. However, EMA's regulations are confined to a specific framework for MDs (Regulation (EU) 2017/745 and IVDs (Regulation (EU) 2017/746) (European Medicines Agency, n.d.).

CE marking is a mandatory certification for products under specific EU regulations, signifying compliance with EU safety, health, and environmental protection standards (European Union, 2024). This mark, which must be visible, legible, and permanent on products, indicates that all relevant directives have been met. Using the CE mark on products not covered by these regulations is illegal. Although the CE marking does not expire, the accompanying EU Declaration of Conformity must be kept current to reflect any changes in legislation, product specifications, or manufacturer details.

In the United States, the Food and Drug Administration (FDA) is responsible for ensuring public health by overseeing the safety, efficacy, and security of human and veterinary drugs, biological products, and MDs (USAGov, n.d.). Despite the regulatory differences, both the EMA and FDA participate collaboratively in the International Council on Harmonization, the International Coalition of Medicines Regulatory Authorities, and the World Health Organization to set standards and policies at a global level, thereby regulating and certifying MDs and diagnostics internationally.

3.3 Categories and classifications

With its innovative contributions, MedTech is typically divided into three main categories, highlighting its diverse impact on healthcare (MedTech Europe, n.d.).

Medical Devices (MD)

MDs encompass various instruments, products, solutions, or services designed to support healthcare by preventing, diagnosing, monitoring, treating, and caring for patients. These devices can vary widely, including implants, software, appliances, apparatus, and instruments, each tailored to meet specific medical needs.

In Vitro Diagnostics (IVD)

IVD refers to technologies that analyze biological samples to assess a person's health status. Utilizing non-invasive methods, these tests examine tissue, urine, or blood samples. The primary goal of IVD technology is to provide information and data to patients, facilitating informed decision-making rather than direct treatment.

Digital health solutions

Digital health solutions represent the intersection of MedTech and data, offering tools and services that leverage information and communication technologies (ICTs) to improve healthcare and lifestyle. These solutions harness the power of digital data to improve delivery, patient engagement, and health outcomes.

These categories incorporate diverse classifications within each category, tailored to the requirements associated with different risk factors, each adhering to specific criteria (Gonzalez-Moral et al., 2023; McDermott et al., 2022). The categories and classifications are illustrated in Figure 3.2. The classification system has become an extremely important tool since it can guide a third party in the assessment process (APACMed, n.d.). The foundational principle of the system is that a higher classification signifies increased risk, thereby demanding and necessitating greater regulatory controls.

To ensure the sustained safety and efficacy of MDs, and due to their extensive diversity, the EMAs categorize these devices into four classes. These classes, Class I, IIa, IIb, and III, reflect the level of risk they pose and their potential impact on the human body and significant health risk potential (Letourneur et al., 2021; McDermott et al., 2022); MedTech Europe, n.d.). Similarly, the European framework organizes IVDs into Classes A, B, C, and D, with Class A being the lowest risk category and Class D the highest. In contrast, the FDA regulations classify MDs and IVDs into three classes: Class I, II, and III (Health, 2023a, 2023b). Digital health solutions outside the conventional MD or IVD classifications are subject to alternative regulations and guidelines (Health, 2020). These may encompass the General Data Protection Regulation (GDPR) for managing personal data and various national statutes pertinent to digital healthcare applications.

Additionally, the criteria and requirements for MedTech assessment and evaluation differ among regulatory agencies (Gonzalez-Moral et al., 2023). These differences affect the timing and way in which information is shared with regulatory bodies and its availability to the broader public. To ensure careful compliance, developers and providers must assess their products against applicable regulations.

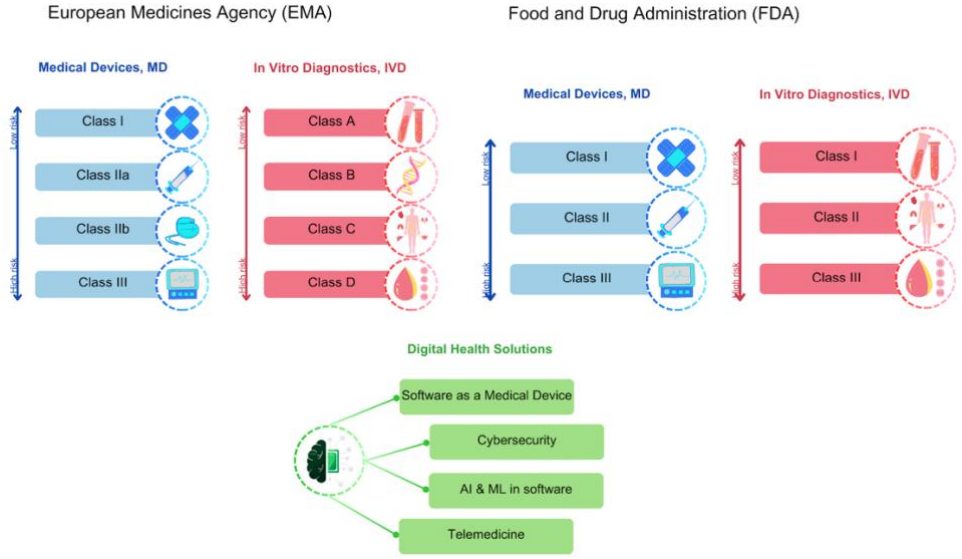

Figure 3.2 EMAs and FDAs Classification of Medical Devices, In Vitro Diagnostics, and Digital Health Solutions.

3.4 The future of MedTech: Europe and United States

The MedTech industry represents a vital sector in global healthcare, with the United States and Europe being pivotal players. In 2021, North America accounted for 36% of the global MedTech revenue, with the US MedTech industry establishing itself as the leader in the sector (Statista, 2024a). The EU followed closely, contributing 28.9% and ranking as the second-largest market. The global MedTech industry, with established centers in the US and Western Europe, was valued at approximately €550 billion in 2021, showcasing its substantial impact on healthcare.

Based on manufacturing prices in 2022, the European MedTech market was estimated at €160 billion (Statista, n.d.). This contribution is expected to increase at an annual growth rate of 4.18% from 2024 to 2028, leading to a projected market volume of $197,3 billion by 2028. Meanwhile, compared globally, North America is expected to generate a revenue of $215.80 billion in 2024 (Statista, 2024b). Furthermore, the United States is the primary import supplier of MDs to Europe, accounting for 45.3% of the total imports, underlining its significant market share.

Key drivers for such steady, consistent growth include the aging population, the spread of health services, and the implementation of technological changes (Statista, n.d.). These elements contribute to the sustained and consistent expansion of the

MedTech industry, highlighting the sector's adaptability and its pivotal role in advancing healthcare.

Despite the expected market growth, the MedTech industry faces continuous and rapid shifts, presenting future challenges (Deloitte, n.d.; McKinsey & Company, 2023). The current challenges stem from a confronting macroeconomic climate by high inflation, constrained capital markets, geopolitical tension, and supply uncertainties. To foster expansion, MedTech leaders must innovate in value creation and stay ahead of evolving trends. Navigating this landscape to promote innovation, growth, and enhanced value creation necessitates appropriate strategies. Moreover, the environmental, sustainable, and governance (ESG) considerations have gained prominence, influencing shareholder decisions and becoming imperative for MedTech companies to address. Implementing a systematic approach to ESG can unlock new value opportunities, underlining its importance for future success.

4 Theoretical background

This chapter provides a theoretical background on circular economy (CE) and outlines its practical implications for MedTech companies. It sets the stage for interpreting the empirical data and understanding the shift towards circularity in the industry.

4.1 The concept of circular economy

The circular economy (CE) represents a fundamental shift from traditional linear economic models towards a system that emphasizes resource reutilization and promotes sustainable management of resources (D'Amato et al., 2017; Murray et al., 2017; Pieroni et al., 2019). As an increasingly recognized solution to environmental and economic challenges, this model advocates for a system where waste is minimized, and resources are constantly recycled back into the economy. It is characterized as a closed-loop system, aiming for an economically efficient system that integrates environmental sustainability, as illustrated in Figure 4.1 (Awan and Sroufe, 2022; Geissdoerfer et al., 2020; Grafstrom and Aasma, 2021; Lewandowski, 2016a; Nussholz, 2017; Pieroni et al., 2019; Ronn et al., 2023). At its core, CE adopts a comprehensive approach that emphasizes environmental sustainability, economic development, and resource efficiency (Europe, 2018; Geissdoerfer et al., 2020; Gil-Lamata and Pilar Latorre-Martinez, 2022). A CE is defined as:

an economic system that is based on business models that replace the 'end-of-life' concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations (Kirchherr et al., 2017, p. 225).

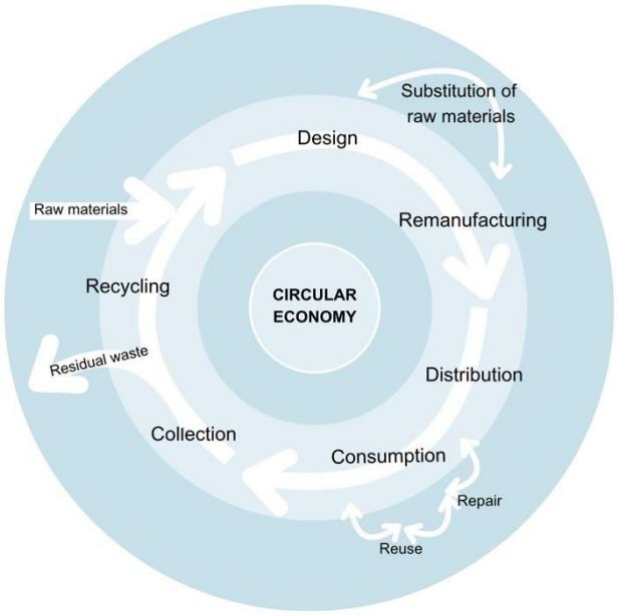

Figure 4.1 Illustration of the CE, inspired by Europe (2018) and Grafstrom and Aasma (2021).

The strategic objective of CE is to minimize environmental impacts by drastically reducing the inputs and outputs of waste (Awan and Sroufe, 2022; D'Amato et al., 2017; Singh et al., 2022). A critical element of this strategy involves embracing the "four Rs": reuse, remanufacture, repair, and recycle. These practices are not just about environmental responsibility but also about designing products and services that support longevity and circularity, leading to significant cost savings and enhanced reputation. The shift towards circularity offers businesses substantial benefits and necessitates significant organizational structure and process changes (Tan et al., 2022). Effective transition management is crucial, requiring a deep understanding of how value creation can be sustained and the role of CE in driving sustainability within business models (Barros et al., 2021; D'Amato et al., 2017; Grafstrom and Aasma, 2021; Nussholz, 2017).

4.2 Business models and sustainability

Building on the principles of the CE within the healthcare sector, including MedTech, business models (BMs) are evolving from traditional linear frameworks to more sustainable, circular frameworks. These new models emphasize resource efficiency and value creation within closed loops, making a significant shift towards sustainability (PricewaterhouseCoopers, n.d.). In management studies, BMs are theoretical constructs and practical tools that can be leveraged to drive sustainability. They are defined as "simplified representations of the value

proposition, value creation and delivery, and value capture elements and the interactions between these elements within an organizational unit" (Geissdoerfer et al., 2018, p.403). A BM provides the organizational and financial framework for delivering customer value (Bocken et al., 2014). This is underpinned by various academic contributions that regard BMs as crucial structures for value proposition, creation, and capture, essential for maintaining competitive advantage (Geissdoerfer et al., 2020; Teece, 2010; Winterhalter et al., 2017). The importance of a robust BM, underscored by the work of critical scholars such as Zott and Amit (2010), Teece (2010), and Osterwalder and Pigneur (2010), highlights the crucial role of innovative BM processes in achieving and sustaining a competitive edge.

These experts present diverse yet converging perspectives on BMs. Teece (2010) focuses on how BM fundamentally defines how a business delivers value to its customers and converts it into profits. Osterwalder and Pigneur (2010) describes and divides a BM into core elements: customer segments, value propositions, channels, relationships, essential resources, activities, partnerships, revenue streams, and cost structure. Zott and Amit (2010) view BMs from an activity system perspective, suggesting a trend towards network-centric BMs rather than single firm-centric ones.

Sustainable Business Models (SBMs) are crucial for integrating sustainability into the core of traditional business frameworks revising conventional structures to include environmental, social, and economic dimensions (Bocken et al., 2014; Geissdoerfer et al., 2018). This holistic approach aims to achieve a triple bottom line, ensuring long-term success while promoting a paradigm shift towards sustainability (Barros et al., 2021; Bocken et al., 2014; D'Amato et al., 2017; Geissdoerfer et al., 2018). Recognized increasingly as crucial for businesses aiming to transition to sustainable practices, adopting SBMs highlights the importance of collaborative efforts across various stakeholders and sectors. It suggests that generating sustainable value is not a solitary endeavor but one that benefits from cooperative rather than isolated approaches (Teece, 2010; Zott and Amit, 2007). At their core, SBMs strategically integrate social, economic, and environmental considerations into business operations, minimizing environmental impacts and promoting economic prosperity and social equity (Guzzo et al., 2020; Khan et al., 2022; Wadin and Ode, 2019). This balanced approach to corporate responsibility also acts as a catalyst for innovation, driving technological, social, and organizational changes. These innovations align with sustainability goals, creating new opportunities for businesses to thrive while positively impacting the world (Wadin and Ode, 2019).

4.2.1 Circular business models

Circular business models (CBM) are an evolution of traditional BMs specifically designed to enhance circularity in business activities (Dagilienė and Varaniūtė,

2023). Though incorporating the core principles of the CE, reuse, remanufacture, repair, and recycle, CBMs strive to close the loop in product life cycles and business operations. Essentially, CBMs expand the triple bottom line approach by operationalizing CE concepts. These models are driven to minimize environmental impacts and innovate in creating value from waste materials (Khan et al., 2022). It can be achieved through strategies that enhance the use intensity and extend the life of products (Bocken et al., 2019; Nussholz, 2017). CBMs are defined as:

business models that are cycling, extending, intensifying, and/or dematerialising material and energy loops to reduce the resource inputs into and the waste and emission leakage out of an organizational system. This comprises recycling measures (cycling), use phase extensions (extending), a more intense use phase (intensifying), and the substitution of products by service and software solutions (dematerialising) (Geissdoerfer et al., 2020, p. 7).

Integrating CE practices into business modeling underscores value creation, a collaborative endeavor enhanced by partnerships across industries and sectors. These models challenge companies to rethink their operational strategies to promote sustainability through a circular lens, indicating that isolated efforts are less effective than collective actions in achieving sustainable outcomes (Bocken et al., 2014; Geissdoerfer et al., 2018; Lewandowski, 2016). Geissdoerfer, Vladimirova, and Evans (2018) highlights the interconnections between BMs, SBMs, and CBMs, positioning CBM as a subcategory of SBM. The correlation between traditional, sustainable, and circular BMs is illustrated in Figure 4.2.

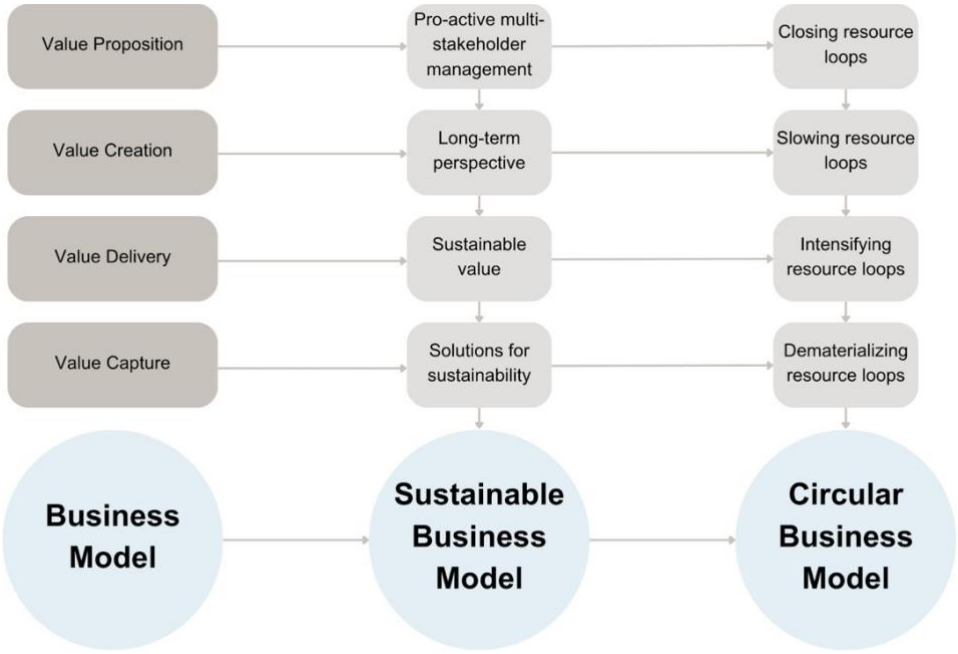

Figure 4.2 The correlation between traditional, sustainable, and circular business models, inspired by Geissdoerfer et al. (2018).

4.3 Business model and circular business model strategies

Building on the foundational understanding previously established, the Business Model Canvas (BMC), initially conceptualized by Osterwalder and Pigneur (2010), serves as a structured and strategic management tool for designing, visualizing, and innovating BMs. The BMC encourages critical analysis through crucial questions focused on 'what,' 'how,' 'why,' and 'who' elements, allowing for clear visualization and systematic evaluation of how a business operates within its ecosystem (Gassman et al., 2013; Osterwalder and Pigneur, 2010). The adapted version of the BMC used in this research is illustrated in Figure 4.3.

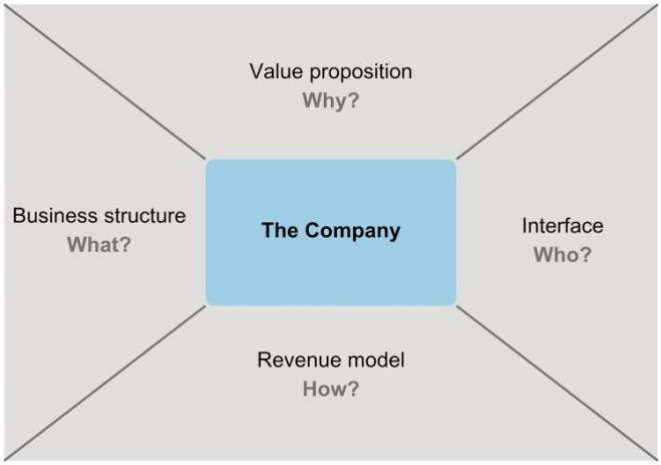

Figure 4.3 An illustration of a simplified version of the Business Model Canvas, inspired by Osterwalder and Pigneur (2010) and Gassmann, Frankenberger and Csik (2013) to better understand an organization's business model.

Researchers such as Bocken, de Pauw, Bakker, and van der Grinten (2016), Geissdoerfer et al. (2020), and Lewandowski (2016) have effectively utilized and modified the BMC to explore the integration of CE practices within BMs. These adaptations of the BMC for CBMs incorporate strategies designed to slow resource consumption, close resource loops, and reduce input through increased resource efficiency. This is especially relevant in the MedTech sector, where sustainable practices are critical for extending the lifecycle and usage of medical devices.

Adopting Circular Business Model Strategies

Adopting CBM strategies within the BMC framework allows organizations to

enhance their sustainability significantly. These adaptations help refine value propositions by incorporating sustainable sourcing and targeting customer segments attracted to circular offerings (Lewandowski, 2016). Organizations can better understand how to effectively integrate CE practices across all aspects of their business, from value proposition to customer engagement and revenue models. This holistic approach minimizes environmental impact, extends product life cycles, and optimizes resource use, enhancing overall sustainability.

Geissdoerfer et al. (2020) outline four primary generic strategies for CBMs, each designed to address different aspects of sustainability and operational efficiency:

- Cycling: Focuses on recycling materials and energy within the system to minimize waste.
- Extending: Aims to prolong the use phase through durable design and maintenance.
- Intensifying: Seeks to enhance the intensity of product use through sharing models.
- Dematerializing: Involves replacing hardware with software to maintain functionality while reducing material use.

These strategies are not only foundational to developing CBMs but are also adaptable depending on the specific needs and capabilities of the organization.

Tailoring strategies to specific needs

CBM subcategories further refine the main strategies, tailored to meet diverse business needs and sustainability goals. Each subcategory supports various aspects of circularity, from resource efficiency to extending product lifespans and enhancing digital solutions. For instance, a subcategory might focus on high-tech medical devices, employing strategies of expanding and intensifying to maximize their lifecycle and usage. Researchers such as Colombo, Gaiardelli, Dotti, and Boffelli (2021), Forum for Future (2018), Pieroni, McAloone, and Pigosso (2020), and Woldeyes, Muffatto, and Ferrati (2023) have categorized these subcategories based on the strategies they employ to achieve circularity. These classifications and their detailed descriptions are provided in Appendix C.1.

To facilitate the application of CBM strategies, various frameworks, tools, and models are available to help businesses develop and implement CBMs effectively. These tools are designed to assist companies in adopting CBMs in a manner that ensures both sustainability and practical viability. A comprehensive summary of these essential CBM tools, identified in research and detailing their application across different stages of product design and business model transformation, can be found in Appendix C.2. This resource is crucial for businesses looking to integrate CE practices in a structured and impactful way.

Businesses, particularly in the MedTech sector, can transform their operations to be more sustainable, resource-efficient, and aligned with CE practices by systematically applying these strategies and tools. These tools support

environmental sustainability and enhance overall business efficiency and market competitiveness.

4.4 Business model innovation and circularity

Business Model Innovation (BMI) involves transforming existing BMs to develop new ones or enhance existing ones (Geissdoerfer et al., 2018). This process is crucial for maintaining competitive advantage and adapting to environmental changes. It encompasses ideation, implementation, and evaluation aimed at diversifying, acquiring, or transforming BM in response to evolving market demands (Foss and Saebi, 2017; Pieroni et al., 2019). The BMI process can foster innovation by:

- Helping companies commercialize new technologies and ideas.
- Viewing the business model itself as a source of innovation and competitive advantage.

Additionally, BMI catalyzes within companies, aiding in the successful commercialization of new ideas, which depends on understanding market development dynamics to introduce, position, and scale innovation effectively. Massa and Tucci (2013) illustrate how companies at different stages in market development innovate at different dimensions, see Figure 4.4. Companies in the introduction phase focus on product innovation, and companies in the growth phase focus on process innovation. BMI only becomes relevant when the companies have reached maturity. This underscores the importance of market maturity in determining the applicability of BMI.

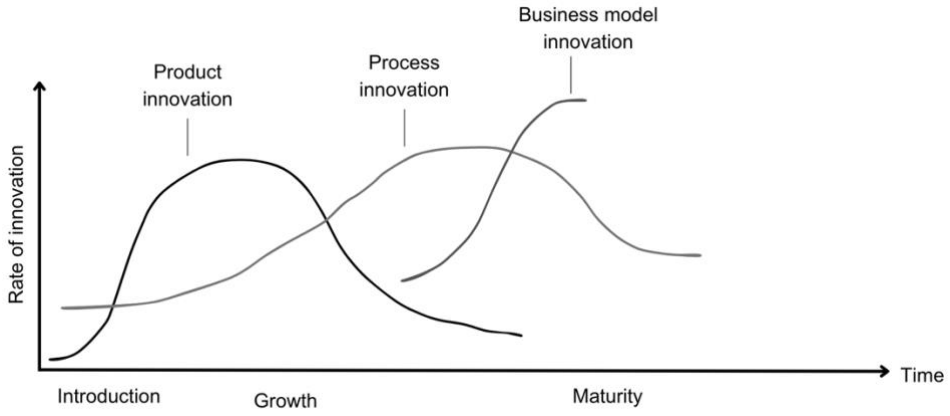

Figure 4.4 Market maturity and innovation (Massa and Tucci, 2013).

BMI activities include designing, creating, implementing, and validating new business models and responding to both internal and external incentives (Massa and Tucci, 2013; Foss and Saebi, 2017; Geissdoerfer et al., 2018; Pieroni et al., 2019). Teece (2007) further details three stages:

- Sensing: Detecting new opportunities and thereby generating innovative new business model ideas.
- Seizing: Systematically experimenting and refining new business model configurations or concepts.
- Transforming: Cultivating new competencies and enabling organizational renewal.

Categorizing BMI into two distinct concepts, business model design, and business model reconfiguration, helps stakeholders understand the appropriate strategies for their specific contexts (Massa and Tucci, 2013). Business model design is tailored to create new BMs in emerging markets, involving activities from creation to validation. Conversely, business model reconfiguration focuses on modifying existing models through organizational resource reconfiguration or acquisition, which is crucial for businesses needing to adapt to changes in their operating environment or capitalize on new technologies.

Expanding on these themes, Circular Business Model Innovation (CBMI) is essential for reshaping business models to integrate and capitalize on CE practices. The connection between the concepts of CBMI, CBM, and CE is illustrated in Figure 4.5 below. As noted by Bocken, Strupeit, Whalen, and Nußholz (2019), CBMI is not just a conceptual approach but a dynamic and interactive process that spans ideation, implementation, and evaluation. These stages foster various degrees of innovation as businesses align their value-creation logic with CE practices.

The principles of CE can be integrated into BMs at different levels, tailored to chosen strategies and decision-maker ambitions (Pieroni, 2019: Kaipainen et al., 2022). The models for integrating these principles are:

- Downstream circular: Focuses on transforming value capture and delivery, typically through new customer interfaces and revenue schemes.
- Upstream circular: Aims to alter the value creation system, redefining resource use and management within the business.
- Fully circular: Combines downstream and upstream strategies for maximum impact, enhancing economic and environmental benefits.

The literature offers several tools, models, and networks to support the development and implementation of CBMI, ranging from practical guidelines to analytical tools. These resources assist in designing, executing, and evaluating the effectiveness of CBMs. Bocken et al. (2019) present thirteen distinct tools for CBMI, detailed in Appendix C.3, which guide companies through the transition towards sustainable and circular operations. These tools ensure that each process step is grounded in actionable strategies that lead to successful outcomes.

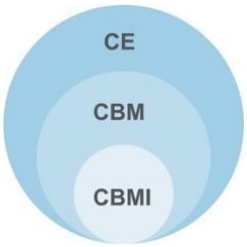

Figure 4.5 The connection between CBMI, CBM, and CE.

4.5 Adopting business models in healthcare and MedTech

BMs and CBMs are pivotal in driving innovation and enhancing sustainability across various sectors, significantly impacting the healthcare sector. These models adapt effectively to address healthcare's unique challenges and opportunities and extend into the MedTech industry.

Studies on healthcare BMs highlight strategies to boost sustainability and operational efficiency, which are increasingly relevant insights to the MedTech sector. However, the MedTech industry presents unique challenges, including technology development, regulatory compliance, and fast-paced innovation cycles, necessitating a more tailored examination (PricewaterhouseCoopers, n.d.). Applying principles from general and sector-specific BM and CBM frameworks necessitates carefully selecting which components are directly transferable to MedTech and require modifications. This critical analysis involves extracting applicable lessons from existing BM strategies and tailoring them to meet the particular needs of the MedTech field. Such strategic adaptations are designed to meet broader sustainability goals while satisfying the specific demands of the MedTech industry, thus enhancing the efficacy of BMIs in these closely related sectors (Marquet and Vetters, 2023).

For the MedTech industry to adopt CBMI and CBM, it must adopt the CE concept and its principles, as illustrated in Figure 4.6. As previously mentioned, the concepts build on each other, and therefore MedTech companies must start with CE before they can reach CBM and CBMI.

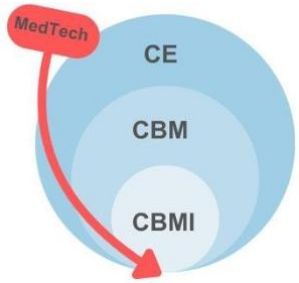

Figure 4.6 Adopting circularity in MedTech.

4.5.1 Trade-offs among circular strategies

Kane, Bakker, and Balkenende (2018) have highlighted the significance of circularity in product design strategies across the healthcare sector, specifically targeting medical devices. Their research underscores the importance of reuse, remanufacture, repair, and recycling processes. They introduce the product value vs. criticality matrix, referred to as the trade-off matrix. This framework aids MedTech companies in selecting the most appropriate CBMs by evaluating medical devices' economic value and health risks.

Building on this framework, Guzzo, Carvalho, Balkenende, and Mascarenhas (2020) refine the matrix to better balance circular design approaches. This improved version of the matrix provides a visual and strategic tool that helps healthcare and MedTech companies maximize their circularity potential, thus paving the way for future innovations and improvements in sustainable practices. The matrix, adaptable across various industries, is visually represented in Figure 4.7, illustrating its role as a practical guide in sustainable practices.

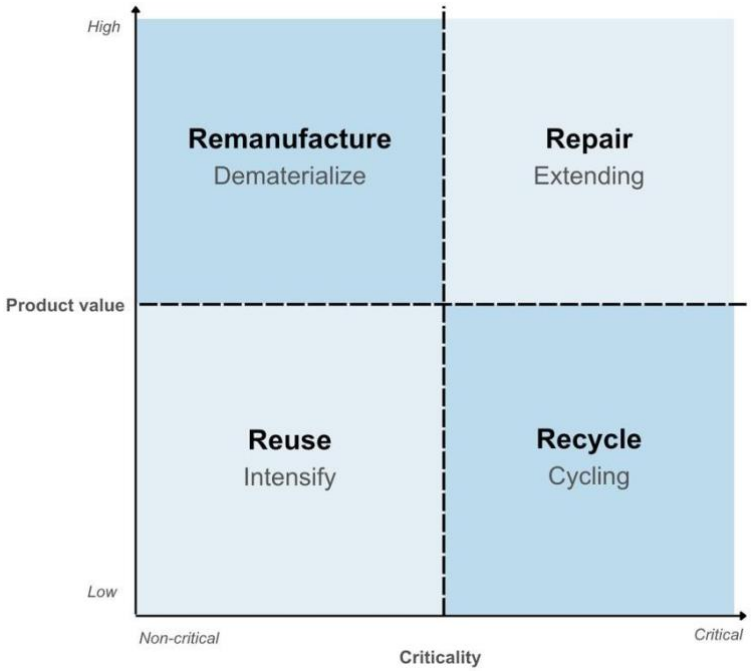

Figure 4.7 Trade-off matrix inspired by Kane et al. (2018) and Guzzo et al. (2020).

The matrix categorizes medical devices based on their functionality and associated risks (Guzzo et al., 2020). High-value devices typically feature complex technology and extensive supplier networks, while low-value devices are more simple and technologically basic. The criticality axis of the matrix classifies devices according to the health risks they pose, using the "Spaulding scale" to determine the necessary level of disinfection (McDonnell & Burke, 2011). This scale categorizes medical devices as critical, semi-critical, or non-critical based on their potential infection risks during patient use, guiding healthcare professionals in appropriate disinfection practices.

This tool classifies devices and identifies opportunities for integrating CE practices effectively within company operations (Guzzo et al., 2020). It informs strategies like refurbishment for high-value, low-risk devices and more intensive reprocessing for devices with significant health risks, thereby enhancing the practical application of CBMs within the healthcare sector.

5 Literature review findings

This chapter presents the findings from the literature review, which addressed the research questions. The insights gathered from this review offer essential context and set the stage for the case study findings presented in Chapter 6.

The circular economy concept introduces a transformative approach to production and consumption, highlighting the need for substantial organizational and operational changes (D'Amato et al., 2017; Pieroni et al., 2019). A comprehensive literature review reveals that adopting CE practices involves a complex interplay of factors driven by both internal and external influences. The various areas found in the literature are illustrated in Figure 5.1 below.

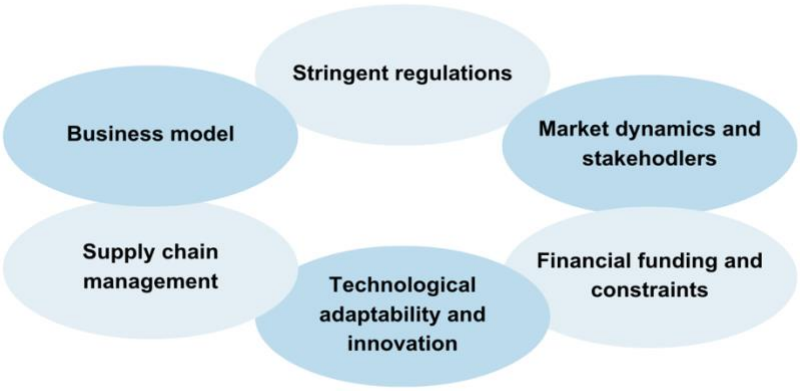

Figure 5.1 The different areas affecting the adoption of circularity in MedTech: found in the literature.

5.1 Stringent regulations

The literature on CE practices in healthcare, particularly as it extends into the MedTech industry, primarily focuses on the stringent regulations that govern this sector. As detailed in Chapter 3, the medical device sector is among the most regulated globally, reflecting the significant risks associated with these products

(McDermott et al., 2022). These strict government regulations limit recycling options and reprocessing activities and highlight a critical tension between risk management and patient safety. They underscore the challenge of maintaining health while minimizing the risk of spreading diseases, a central concern in the medical device sector (Guzzo et al., 2020). This tension reflects the complex balance that must be achieved between ensuring safety and embracing practices that support sustainability and circularity in healthcare. This paradox often hinders the adoption of CE practices, as the rigid regulatory framework prevents the reprocessing and reuse of medical devices, posing substantial barriers to sustainability. Regulatory bodies such as the EMA and FDA enforce mandatory requirements for market entry, which, while ensuring safety, also impose significant challenges for the integration of CE practices within the MedTech industry (Akano et al., 2021; Guzzo et al., 2020; Rosati et al., 2023).

Despite these challenges, there is a growing need to reconcile the rigidity of safety regulations with the flexibility required for sustainable practices (Gonçalves and Franco, 2024; Ishaq et al., 2024). The healthcare industry's reliance on single-use devices presents a critical point of contention (Ishaq et al., 2024). The stringent regulatory environment ensuring patient safety significantly restricts the recycling options. It complicates the adoption of circular technologies, creating a notable conflict with the principles of a CE. This situation necessitates innovative approaches to regulatory compliance and waste management strategies, where sustainable practices must be balanced with uncompromising safety standards (Gonçalves and Franco, 2024; Ishaq et al., 2024). Enhancing the effectiveness of internal regulatory paradigms is therefore crucial, requiring a supportive environment that encourages the recycling and reuse of medical devices.

This section also examines the dual role of internal policies and regulatory frameworks within organizations as drivers and barriers towards sustainability and CE practices. The literature stresses the importance of aligning internal policies with the Sustainable Development Goals (SDGs) to unlock innovative sustainability pathways (Awan and Sroufe, 2022; Rosati et al., 2023). While excessively stringent regulations may restrict innovation and CE practices, well-designed policies aligned with global sustainability goals can promote sustainable operations, enhance collaboration, and facilitate transitions to CBMs (Awan and Sroufe, 2022). Emphasis is placed on the need for managerial strategies that assess and adjust internal policies to actively promote SDG-aligned innovations, providing organizations with a strategic framework to overcome sustainable transformation challenges (Rosati et al., 2023).

Product design requirements for circular products also present significant barriers to circular business model innovation (CBMI) (Guldmann and Huulgaard, 2020). Regulations directly impacting product design and functionality need careful consideration to ensure they do not conflict with the regulations. Governmental regulations can further impede the implementation of CBMI and broader transitions towards a CE (Benz, 2022). Effective legislation, consistent across countries, is also

necessary to facilitate long-term business success and support a transformation towards a CE. Additionally, public procurement policies, often more cost-oriented than sustainability-oriented, can hinder CBMI implementation. Therefore, a comprehensive national circular strategy is essential for guiding companies towards embracing CE practices and achieving sustainable innovation.

In addition, economic incentives play a critical role in influencing the viability and attractiveness of circularity within the healthcare sector (Vermunt et al., 2019). Regulatory institutions shape incentives for specific behaviors by altering economic payoffs, thus pivotal in guiding entrepreneurs' actions and influencing economic activities (Grafstrom and Aasma, 2021).

5.2 Market dynamics and stakeholders

The market dynamics encompass the forces that shape the business environment directly impacting the implementation of CE practices. The literature emphasizes the importance of market engagement and policy reform to unlock CE opportunities within the healthcare sector (Gaberščik et al., 2021)

Literature highlights the importance of industry-wide collaboration in fostering CE practices in the healthcare sector (Ishaq et al., 2024). This collaborative effort, spanning stakeholders such as manufacturers, healthcare providers, and waste management entities, cultivates a synergistic environment conducive to embracing CE principles. These entities can drive innovation, enhance resource efficiency, and contribute to more sustainable healthcare systems by working together. However, literature revealed that the market is characterized by strong stakeholder resistance, inadequate economic incentives for circularity, and a market rooted in a linear economy mindset (Grafstrom and Aasma, 2021; Vermunt et al., 2019). The lack of consumer interest and stakeholder resistance underscores the need for education and policy incentives to shift the paradigm towards a CE (Gaberščik et al., 2021). The sector's slow progress towards sustainability underscores the urgency for incentives that promote circularity. In this environment, companies that reprocess, remanufacture, and recycle, effectively communicating the value of CE practices to stakeholders, could be pivotal in driving the market towards embracing CBMs.

A strategic emphasis on identifying and leveraging opportunities aligned with the SDGs, fostering a culture of innovation, and providing sufficient resources is crucial for catalyzing business model innovation (BMI) and achieving sustainable growth (Rosati et al., 2023). This perspective underscores the interplay of market dynamics and stakeholders, emphasizing the need for an environment conducive to innovation and collaboration. In this context, internal BMI emerges as a driver towards CE practices, necessitating a collaborative ecosystem where creative and circular

solutions can be developed and implemented effectively (Rosati et al., 2023; Singh et al., 2022). The literature further emphasizes the significance of organizational synergy, highlighting the effective alignment and cooperation among different departments and stakeholders. This collaboration is deemed essential for embedding sustainability into the core of BMs. Furthermore, an integrated approach is advocated, leveraging the opportunities provided by the SDGs to drive CE practices and instigate transformative change (Rosati et al., 2023).

This challenge involves financial aspects and allocating time, personnel, and other necessary resources for such a transformation. It is particularly problematic for small and medium enterprises (SMEs), which often operate with constrained resources and may struggle to afford the initial capacity and investment required for adopting CE practices (Gonçalves and Franco, 2024; Guzzo et al., 2020). The difficulty in presenting clear and compelling business cases for CE adoption complicates securing necessary funding from stakeholders (Gonçalves and Franco, 2024). It often results in inadequate resource allocation, where a frequent lack of prioritization within organizations for sustainable practices and decision-making is evident (Assmann et al., 2023; Gaberščik et al., 2021; Grafstrom and Aasma, 2021).

Regulation and stakeholder coordination emerge as pivotal external factors shaping the transition towards circularity in the MedTech industry. Given the many stakeholders involved, effective regulatory oversight becomes essential to harmonize their efforts and distribute responsibilities accordingly (Guzzo et al., 2020). Facilitating knowledge exchange and resource pooling among stakeholders becomes imperative to address challenges and circular opportunities. MedTech companies can exhibit adaptability and flexibility through collaboration and cooperation, particularly when exchanging expertise with stakeholders. This concerted effort among stakeholders ensures the implementation of best practices and innovative solutions, thus fostering effective circularity promotion (Ishaq et al., 2024). Such collaboration facilitates knowledge dissemination and streamlines company communication and processes, advancing CE practices.

Furthermore, collaborative and open innovation emerges as a cornerstone for the industry's transition towards circularity (Geissdoerfer et al., 2018). This strategic approach is complemented by the dynamic capabilities inherent within companies, which enable them to adeptly sense emerging trends, seize circular opportunities, and overhaul operational practices in favor of sustainability (Ishaq et al., 2024). By leveraging these dynamic capabilities, firms can effectively implement CE practices, facilitating the transition toward circularity.

5.3 Financial funding and constraints

High capital investments and substantial funding characterize the MedTech industry. Therefore, financial support provided by governments or other institutions,

alongside tax incentives and regulatory frameworks, serves as crucial economic tools (Grafstrom and Aasma, 2021). However, lack of funding and resource constraints emerge as a challenge, particularly problematic for SMEs (Gonçalves and Franco, 2024). These businesses often operate with limited resources and may struggle to afford the initial capacity and investment required for adopting and exploring CE practices (Gaberščik et al., 2021; Gonçalves and Franco, 2024; Guzzo et al., 2020).

Difficulties in securing funding from banks or public sources can significantly obstruct the implementation of CBMIs (Guldmann and Huulgaard, 2020). This challenge is frequently linked to unclear market demand for such practices (Grafstrom and Aasma, 2021; Vermunt et al., 2019). Subsidies and financial incentives are crucial for supporting CBMI implementation and can be critical factors in overcoming these financial barriers (Benz, 2022). Additionally, ensuring economic viability is essential, as businesses must secure adequate financing to implement their models successfully.

The literature reveals a significant research gap on CBMs within MedTech, particularly noting the limited evidence available regarding their environmental and economic benefits (Guldmann and Huulgaard, 2020). This scarcity of data contributes to increased investment risks associated with these models. Despite these challenges, adopting CE practices could result in substantial cost savings for patients and healthcare systems. However, further research is needed to substantiate these claims (Ishaq et al., 2024). Given these gaps, fostering collaborations with the academic sector could be pivotal for advancing CBMI within companies (Benz, 2022). Effective partnerships across academic, private, and public sectors are crucial for successful cross-sector collaboration, as these relationships can drive innovation and provide more comprehensive insights into the benefits and challenges of circular models (Benz, 2022).

Moreover, a significant knowledge gap in practical guidance within organizations about implementing CE practices further complicates these financial challenges (Assmann et al., 2023; Gaberščik et al., 2021). This lack of practical knowledge leads to uncertainty and results in missed opportunities, exacerbating the financial risks. Recognition of the potential environmental and business benefits of CE practices is emerging. However, the lack of actionable insights creates a barrier, suggesting that managers are risk-averse to making proactive decisions towards circularity, particularly in financially constrained environments (Tan et al., 2022).

5.4 Technological adaptability and innovation

Technological innovation and adoption are critical in driving the MedTech industry toward sustainable and circular economy practices (Brem et al., 2021; Ishaq et al., 2024). Advanced technology, such as Artificial Intelligence (AI), the Internet of

Things (IoT), and 3D printing are revolutionizing medical device design, manufacturing, and waste management, significantly enhancing resource efficiency (Brem et al., 2021; Ishaq et al., 2024; Rosati et al., 2023). Additionally, enabling technologies like advanced monitoring and measurement tools are crucial for companies to track their progress and optimize their CE practices (Benz, 2022).

While these technologies foster innovative and CE practices, integrating them seamlessly into existing organizational structures presents challenges. Strategic utilization of these technologies is essential to promote sustainable practices and advance CBMs. Critical during this transition is the activation of technical cycles such as repair, reuse, refurbish, and recycle, which maintain product value in the post-use phase (Guzzo et al., 2020; Ishaq et al., 2024). These cycles must be "coherently activated considering additional trade-offs to enable circularity in the medical device industry" (Guzzo et al., 2020, p.3). By implementing systems that ensure regular maintenance and safe reuse across different facilities, as well as updating and restoring older devices, MedTech companies can effectively manage the entire lifecycle of their products from design through to end-of-life. Integrating these technical cycles aligns with sustainability goals and reduces the overall environmental impact (Lüdeke-Freund et al., 2018). Furthermore, processing used medical devices to recover materials for new device production involves a strategic combination of synergistic circular strategies that support multiple product lifecycles and extend product lifetimes. This comprehensive approach enhances the usability and functionality of medical devices, meeting current standards and extending their life before they require recycling.

The demand for technical expertise, data availability, product quality, and durability challenges underscore the transition towards CE practices within the MedTech industry. These factors add complexity to operations, highlighting the necessity to maintain safety, quality, and durability without compromising circularity objectives (Benz, 2022; Geissdoerfer et al., 2018; Grafstrom and Aasma, 2021; Vermunt et al., 2019). The integration of circularity into medical devices necessitates establishing roles that stimulate technological innovation and adaptability, ensuring that logistics and supply chain processes are optimized to support these changes (Hofmann and Jaeger-Erben, 2020; Ishaq et al., 2024).

5.5 Supply chain management

Integrating emerging technologies and effective supply chain management is paramount in the rapidly evolving MedTech industry. These elements are critical in enhancing resource efficiency and achieving the objectives of the CE (Benz, 2022; Ishaq et al., 2024). Research highlights the importance of operational supply chain management and its impact on resource efficiency and effectiveness. Challenges such as integrating CE practices into existing processes are prevalent, but insights

from various studies offer successful strategies for overcoming these obstacles. Effective management and strategic partnerships with recycling facilities are essential for fulfilling the CEs goals, with case studies showing benefits like reduced waste and improved resource utilization (Benz, 2022; Ishaq et al., 2024; Gaberščik et al., 2021).

Effective internal communication and collaboration are crucial for adopting CE practices and managing reverse logistics. Organizational culture significantly impacts the openness to these principles, where resistance to change and adherence to outdated sustainability strategies can impede progress. Dynamic organizational dimensions are vital for encouraging innovation and enhancing adaptability, supporting a sustainable transition within the industry (Assmann et al., 2023; Benz, 2022).

Implementing CBMI requires innovative strategies supported by robust supply chain management (Benz, 2022). Practices such as reverse flow management are fundamental in establishing efficient reverse logistics, a core component of circular systems. The effectiveness of these innovations depends on the supply chain's ability to manage globally dispersed and culturally diverse value chains, where a lack of knowledge and competencies can pose significant challenges (Benz, 2022; Guldmann and Huulgaard, 2020). Enhancing supply chain capabilities is thus essential for the successful implementation of CBMs.

5.6 Business model

The structure of business models significantly influences the adoption of CE practices in the MedTech industry. It is critical during this transition to maintain product value in the post-use phase by activating technical cycles (Guzzo et al., 2020; Ishaq et al., 2024). The incentive of cost savings for patients and healthcare, derived from implementing circular design principles, drives the transition towards circularity. Guzzo et al. (2020) present the BM structure as a valuable tool for conceptualizing CBM in the medical device industry. Several MedTech companies are conscientiously committed to minimizing their ecological footprint through careful design and material selection (Ishaq et al., 2024). Design for circularity is an important approach that drives the implementation of circular incentives, supporting companies in navigating the design process to create products intended for multiple life cycles (Ishaq et al., 2024).

Adopting a design thinking approach can offer substantial advantages over traditional project management methods in implementing CBMI, fostering creativity and innovation in tackling complex problems (Benz, 2022). Effective internal communication is crucial for enhancing the understanding of circular strategies and promoting collaboration across various levels of an organization (Gaberščik et al., 2021; Vermunt et al., 2019). It is essential in managing complex

processes like reverse logistics, which are vital for a CE but often encounter significant logistical hurdles. The commitment and involvement of top management plays a critical role in driving the transition to CE and CBMI. Their support fosters dynamic capabilities and cross-functional competencies crucial for successfully implementing CBMI (Benz, 2022; Guldmann and Huulgaard, 2020).

The BMC framework facilitates the implementation of CBMI, aiding companies in navigating design processes to create products intended for multiple life cycles (Nyström et al., 2021; Guzzo et al., 2020). Financial viability is also crucial, and businesses must be able to finance their models to implement CBMI successfully (Benz, 2022). Bocken et al. (2019) further highlight that while numerous tools are available for CBMI, many do not meet specific company needs, leading to underutilization. Therefore, conducting empirical testing and validating these tools is crucial to ensure their practical usefulness.

Implementing CBMI faces various challenges, including the limited number of business modeling methods and tools that effectively incorporate sustainability. Despite the availability of numerous tools, their underutilization due to complexity or inadequate empirical testing still needs to be addressed (Geissdoerfer et al., 2018; Benz, 2022). Additionally, the complexity of global and culturally dispersed value chains can hinder CBMI implementation, necessitating strong management capabilities, particularly in reverse logistics and change management (Guldmann and Huulgaard, 2020; Foss and Saebi, 2017; Hofmann and Jaeger-Erben, 2020).

6 Case study findings

This chapter presents the findings from the interviews conducted with the selected case companies. The findings have been transcribed and compiled using the Gioia methodology.

The subsequent results section presents the data collected from the case studies, illustrating how the theoretical aspects of CE models are being applied or challenged in real-world MedTech practices. During the semi-structured interviews, the case companies provided valuable insights. They offered a comprehensive understanding of circularity within their operations and a nuanced perspective on the practicalities of adopting CE practices. Most companies stated that they do not actively use explicit and specific CE practices. However, after further discussions, it was revealed that there is a commitment to sustainability and innovation. It was also possible to indicate a curiosity about successfully introducing CE practices. The outcomes of these case interviews are presented in Figures 6.2-6.5, utilizing the Gioia methodology. An overview of the identified areas is illustrated in Figure 6.1, which will be discussed in the following subsections.

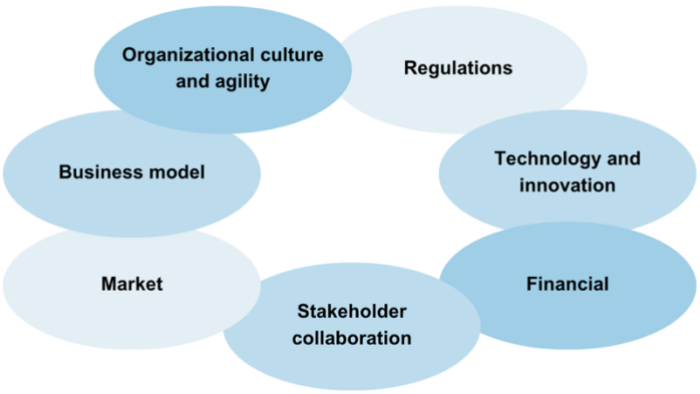

Figure 6.1 The identified areas affecting the adoption of circularity in MedTech: identified from the case study.

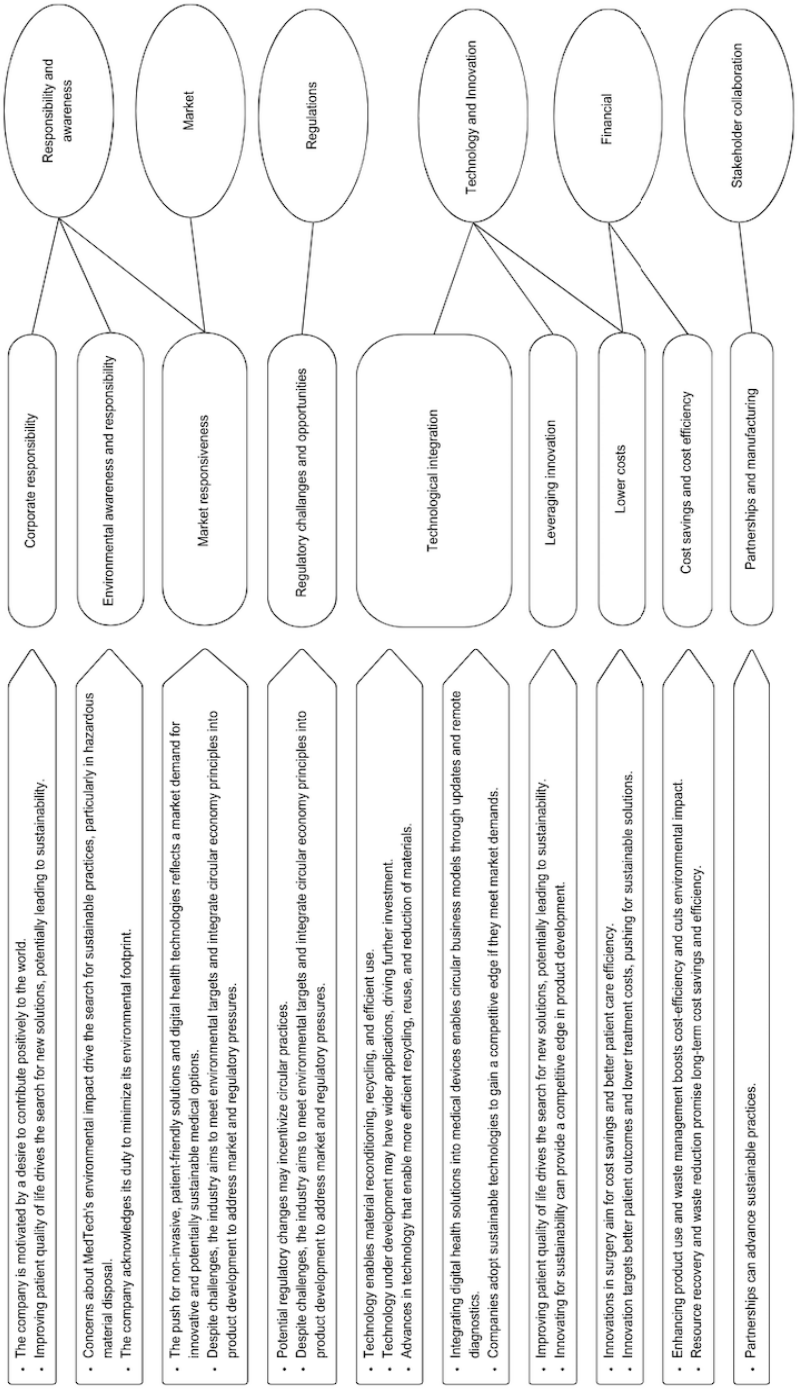

Figure 6.2 Gioia analysis of drivers influencing CE practices within the MedTech industry.

Figure 6.3 Gioia analysis of barriers that influence CE practices within the MedTech industry.

Figure 6.4 Gioia analysis of key factors for adopting CBM among MedTech companies.

Figure 6.5 Gioia analysis of how MedTech companies adopt BMI.

6.1 Regulations

The regulatory environment is a key factor influencing the transition towards circularity in the MedTech sector. The current regulatory and market pressures demand compliance and innovative approaches to how products are designed, manufactured, and disposed of. Despite these challenges, the industry is driven to meet environmental targets and integrate CE practices into product development to address market and regulatory pressure. Aligning with this, the companies expressed the need for a shift in regulatory standards to enable the MedTech industry to adopt CE practices. Various companies stated that a change in regulatory frameworks could better support sustainable innovation and the use of circular materials without compromising patient safety. Influencing regulatory standards could accommodate and actively promote circular approaches, significantly benefiting the transition towards a more sustainable and circular MedTech industry.

The stringent regulations pose significant challenges for MedTech companies in developing and innovating their products and new circular and sustainable processes, slowing the circular transition. The complex regulatory environment created, especially under the new EU regulations in 2021, has notably made bringing new medical devices to market more challenging, slowing the pace of innovation. This regulatory environment becomes a crucial barrier at the crossroads of development. Since the primary objective of the MedTech industry is to improve health and well-being, there is a fundamental priority placed on people's health over the rapid adoption of new technologies. This focus on safety often comes at the expense of quicker innovation and implementation of CE principles.

Reusing and recycling materials and components is a regulatory challenge across the industry. Several regulatory requirements focus on safety and sterility, which often contradict the objectives of the CE. Various companies present the use of regulatory challenge of sterility, a clear example of a situation where safety concerns limit the scope for recycling and reusing materials. A few companies underscore the critical need for reliability in life-saving equipment, making it challenging to use refurbished components, as safety is always the highest priority. Integrating innovative technology within the healthcare sector also becomes challenging due to the industry's safety standards. These strict regulations often make strategic focus inflexible and not adaptive to rapid technological changes, which may prevent companies from adopting new and potentially more sustainable technologies and innovations, further compounding the difficulties of integrating CE principles.

Many companies also discussed the importance of securing regulatory approval. A finding from one of the interviews implied that getting approval and entering the US market is easier, particularly with medical devices. The FDA determines less strict regulations and classifications of medical devices than the EMA. Additionally, due to strict regulations, obtaining regulatory approval is time-consuming, costly, and difficult. However, approval is also crucial as this determines whether the

companies can proceed to a market launch. The process hinders MedTech companies' ability to pursue innovative solutions that expedite the transition to circularity. Due to the difficult approval process in the earlier development phase, MedTech companies prioritize their resources and focus on clinical trials and regulatory requirements rather than innovating or updating their BMs. As a result, few companies prioritize exploring CBMs and CBMIs more than what's required. Clinical trials must demonstrate safety and efficacy in maintaining the highest patient safety standards and regulatory compliance. Regulatory approval becomes essential as the company's business development heavily depends on it.

In addition to regulatory approval, the industry must meet demanding requirements to become CE marked. This reflects the industry's rigorous safety and effectiveness standards, posing another complexity for integrating innovative technologies and adopting more CE practices within the healthcare sector.

6.2 Technology and innovation

Technological integration and leveraging innovation are crucial for adopting CE practices in the MedTech industry. However, the healthcare sector's limited readiness to adopt such innovations poses a significant challenge. This hesitancy necessitates stronger collaboration between MedTech companies and healthcare providers to integrate new technologies seamlessly. Despite these efforts, companies' lack of direct incentives to adopt CE practices remains challenging. Therefore, the companies underscored the importance of interacting with the healthcare sector when adopting innovative technologies.

In contrast, technological advancements enable more efficient recycling, reuse, and reduction of materials, which drives the adoption of CE practices in the MedTech industry. Utilizing technology can also facilitate the reconditioning or efficient use of materials. Integrating digital health solutions into medical devices can also enable CE practices and CBM through leading, updates, and remote diagnostics. A common strategy among companies is to use existing technologies, platforms, and digital channels to enhance their business operations and models. By leveraging these established technologies, companies can focus their efforts and resources on more critical areas of development and innovation. Some companies utilize existing technological platforms to streamline their testing processes, enhancing efficiency and incorporating digital solutions to facilitate day-to-day operations and improve workflow efficiency. Further, digitalization can also be used among companies to aid business processes and renew business models. In addition to using existing technologies, emerging technologies are recognized to create new revenue streams and business opportunities. Focusing on technological advancements is presented to support companies in pursuing BMI, which can drive circular adoption. Despite the limited resource allocation towards circularity, companies point out the need for

technological advancements to support the development and transition towards circularity. They also adopt sustainable technologies to gain a competitive edge.

There are, however, challenges in adapting existing technologies or developing new ones that accommodate the CE practices while maintaining efficiency. For MedTech companies to reprocess medical equipment for health standards is costly and technically challenging, which hinders CE practices. Further, companies discuss that it is also technically difficult to obtain specialized materials for medical devices meeting medical purity and safety standards, hence hindering the development and adoption of sustainable and CE practices. CE practices are also discouraged due to the inherent difficulties in incorporating circular materials in single-use medical products. Introducing new technologies or materials also requires extensive and costly approval processes, which were pointed out as a critical impediment to innovation and sustainability efforts. This complexity is echoed in their struggle to develop and test new solutions, reliant on substantial investment and support from external capital, which may not always favor long-term sustainability goals over short-term returns. Developing advanced technologies for the MedTech industry, such as AI for medical applications to streamline processes and adopt CE practices, may face data security, accuracy, and health regulation compliance hurdles.

Furthermore, a few companies highlight the importance of interaction with the healthcare sector when adopting innovative technologies. The healthcare sector's readiness to adopt innovative technologies is limited, which challenges MedTech companies to adopt new technologies. Therefore, this poses a challenge for companies to adopt CE practices further, as it would be challenging for the healthcare sector to adopt this.

In addition to the technological aspect, leveraging innovation drives MedTech companies towards adopting CE practices. Several companies emphasize the critical need for innovation, particularly in material science, to enable a more circular MedTech industry. New solutions and innovations in material science would enable MedTech companies to adopt CE practices and CBM. Some companies highlight that innovation in product design, material reduction, and integration of new processes could expedite the adoption of CE practices.

Various companies underline the importance of continuous innovation as a key factor in ensuring a successful transition to CE practices. Innovating for sustainability could also give companies a competitive edge in product development. Companies state that committing to innovation means standing out in the competitive MedTech landscape. For some companies, innovation is central to their discussions on development, product application, and new technologies. By integrating these innovations, companies can actively renew their BM, which can be beneficial when adopting CE practices and CBM. Companies state that innovations target better patient outcomes, streamlining patient care and lower treatment costs, contributing to cost savings. This pushes for more sustainable

solutions and supports adopting more CE practices. However, developing new medical technologies, including those with CE practices, entails high costs in compliance and market entry, which could prevent companies from adopting these practices.

6.3 Financial

Financial incentives are crucial in driving the circular transition within the MedTech industry. Financial factors can drive and hinder the adoption of CE practices among companies in the MedTech industry. Applying CE practices that enhance product use and waste management can boost cost efficiency and reduce environmental impact. Resource recovery and waste reduction could also promise long-term cost savings and efficiency, which becomes another incentive for MedTech companies to adopt CE practices. Companies discuss the importance of economic incentives in promoting successful circular transitions. Aligning economic incentives with environmental benefits could enhance the attractiveness of CBMs and promote the adoption of CE practices. This alignment would benefit individual companies and encourage the MedTech industry to embrace circularity. This demonstrates how financial and market-related incentives foster industry-wide sustainable and CE practices. In addition, there is a lack of evidence regarding whether companies benefit financially from adopting CE practices. This aspect has prevented companies from implementing circularity into their businesses.

Lack of funding has been identified as a barrier to adopting CE practices in the MedTech industry, as high capital investments are often required. Therefore, effective capital utilization becomes essential for many companies to advance their product lineup and growth. Significant financial resources are necessary to develop, test, and certify new medical technologies and meet the rigorous standards of regulatory approvals. The high costs associated with investing in new technologies and transforming BMs hinder companies' efforts to adopt more sustainable practices and restrict their development. Extensive costs associated with innovating and manufacturing new technologies that incorporate CE practices, not just in development but also in achieving compliance and market entry, may hinder circular adoption. Some companies pointed out the challenge of securing long-term financing for research, development, and clinical trials, particularly given the extended development cycles characteristic of the MedTech sector.

Furthermore, the majority of companies in the early development phase, as for this case study, rely on external capital and investor support, which often make them prioritize immediate financial returns over long-term sustainability goals. They often focus on commercializing their product to launch it on the market and start raising capital. This further complicates the transition to CE practices. In contrast, one company experiences a unique funding situation that allows them to prioritize

long-term R&D. This financial stability gives them the luxury of focusing on innovation and development without the immediate pressure to commercialize their products.

6.4 Stakeholder collaboration

Partnerships can advance sustainable practices and drive MedTech companies towards adopting CE practices. Collaboration with stakeholders is a key factor influencing the circular transition within the MedTech industry. Various companies stress the necessity of industry-wide collaboration to facilitate the successful adoption of CE practices among individual companies and the industry. Collaboration with stakeholders is essential for developing standards and best practices for circularity that are compliant with industry requirements. Joint forces are crucial for realizing the adoption and transition towards sustainability. Several MedTech companies leverage strategic partnerships to unlock new opportunities and revenue streams. Companies highlight the benefits of such collaborations in providing new business avenues. In addition, there is also a need to create an ecosystem that supports CE principles, emphasizing that collaboration with stakeholders across the supply chain is vital.

Collaborations and partnerships, especially with large industry players, have a significant meaning as they provide significant opportunities for information exchange, sharing expertise, resources, and market access. Various companies discuss their plans to collaborate with larger, established entities and adopt an outsourcing strategy to reduce their go-to-market risks and streamline their operations. By partnering with these players, they aim to capitalize on existing market channels, which could facilitate smoother and more secure market entry. Capitalizing on existing channels could reduce the market entry risk and make it easier for companies to quickly raise funding to support their circular adoption due to increased resource availability. Despite the potential opportunities outsourcing can offer, some companies underscored the risks of sharing information and rather keep the main operations and work in-house. This is to prevent secrecy and internal information from being leaked to competitors.

A few companies highlight the importance of working with municipalities and healthcare providers in the MedTech industry. Such partnerships can lead to joint efforts that foster tailored innovations and solutions, enhancing support for the transition toward circularity. In addition to stakeholders in the value chain and industry players, companies emphasize the significance of collaborating with healthcare providers, research institutions, and regulatory bodies to embrace CE practices. Such collaborations are crucial for accelerating product development, clinical validation, and market entry, as well as for understanding regulations better and to potentially influencing them.

6.5 Market

Market dynamics are crucial for driving the circular transition within the MedTech industry. The MedTech industry aims to meet environmental targets and integrate CE practices into product development to address market and regulatory pressures. The current drive towards developing non-invasive, patient-friendly solutions and leveraging digital health technologies indicates a market demand for innovative and potentially more sustainable medical options in the future. Companies discuss that market incentives are critical for enabling the circular transition in the MedTech industry. There is a special need for larger companies or authorities to champion these incentives and establish new standards to create an industry-wide shift. The influence of larger companies is significant, as they can set new sustainability and circularity standards that smaller companies, often constrained by resources, might struggle to establish independently. Therefore, companies emphasize the importance of continuous market analysis in research and technologies to address challenges associated with moving toward circularity. This ongoing analysis helps companies adapt and respond to emerging trends and technological advancements that can facilitate the circular shift. Continuous innovation, analysis, and adaptation to emerging trends become crucial for overcoming the barriers to adopting CE practices.

The drive to enhance a competitive edge in the market encourages companies to innovate, potentially adopting more sustainable technologies if aligned with market demand. Therefore, the market becomes important in determining whether companies will adopt CE practices. Companies, therefore, also highlight the importance of being adaptable and agile, not only to survive and compete in an innovative market but also to effectively innovate their BM and adapt to market needs. A few companies emphasize marketing over product development to showcase their products' capabilities effectively. This strategy aims to attract and convince potential customers, increasing opportunities to raise capital and funding.

6.6 Business model

MedTech companies face rigid strategic focus due to clear regulatory milestones, hindering adaptability to rapid changes in their BM. Companies discuss the difficulties in changing established practices and overcoming challenges within traditional BMs that may not readily prioritize CE practices. This resistance to change is often compounded by the need to meet investor expectations and manage the high costs associated with R&D.

Additionally, a few companies brought attention to the complexities of implementing circular processes in their production and supply chains. They

emphasized the need to balance the cost implications of adopting CE practices with the financial constraints of the healthcare system, which often leads to a cautious approach toward making bold, innovative changes. These managerial challenges reflect a broader issue where traditional business strategies and the healthcare industry's focus on safety and efficacy may limit the integration of sustainable and CE practices.

MedTech companies face the challenge of adopting circularity and CBM as they are locked to their current products, processes, and BM, which constitutes a barrier to adopting CE practices. A few companies must customize products to meet specific user needs, complicating implementing a standard circular model. They also highlighted the difficulties of navigating a stringent regulatory environment that does not favor reused or recycled components and the logistical challenges of handling varied components that require different recycling processes.

There is also an industry hesitance towards bold sustainability changes, as many companies prefer to minimize risk and stick to pre-approved products. This could be because consumers and stakeholders lack demand and awareness for circular and sustainable products and do not push MedTech companies toward adopting CE practices. Furthermore, companies often face challenges in persuading healthcare providers and patients to accept leasing or reused materials. This hesitance is largely due to stringent regulations and the need for additional time and economic resources, which are necessary to mitigate potential risks to patients. Companies usually want a secure BM that meets customers' and stakeholders' demands and expectations. Therefore, it becomes difficult for companies to adopt CE practices and CBM.

Despite the difficulties of renewing the BM and becoming more circular, several companies are actively working to adopt CE practices into their BMs. One company is investigating the development of less resource-intensive products, demonstrating a proactive approach to sustainability. Another company is implementing technological innovations to minimize environmental impact, and another is shifting its production closer to the point of use to reduce its carbon footprint, a strategic move to enhance sustainability and reflect its commitment to ecological responsibility. While some companies have begun exploring how they can evolve their BM to adopt circularity in the future, others indicated that they have not yet focused on or discussed strategies for adopting CE practices. A mutual statement from all the case companies reveals that circularity is not a core component of their current BM, but they are open to exploring the concept further.

Additionally, it became evident that the case companies did not have an explicit or established process or strategy for renewing and innovating their BM. The companies, however, presented that they create scenarios for product launches and explore and evaluate different BM approaches and opportunities. This is mainly due to exploring how to expand into new market segments, better meet market demand, and create more sustainable customer relationships. Innovation is also important for

companies to renew their BM and differentiate in the MedTech industry.

6.7 Organizational culture and agility

In the MedTech industry, a company culture that fosters openness is critical for nurturing continuous dialogue, innovation, and experimentation. This openness sparks new ideas and facilitates agile development and the effective implementation of innovative processes and strategies, which are essential for adopting CE practices. The mission of MedTech companies is to improve patient quality of life and encourage the pursuit of new solutions that lead to sustainable innovations, thereby promoting circular adoption.

Furthermore, these companies recognize their environmental responsibilities. Despite being overshadowed by regulatory and financial challenges, a strong foundational interest in sustainability exists. This is driven by regulatory compliance and increasingly by societal demands, highlighting the growing importance of reducing environmental impacts within their operations. As awareness of environmental sustainability grows, stakeholders understand that integrating CE practices can complement their healthcare commitments. Recognition of the environmental implications of MedTech products, particularly in disposing of hazardous materials, spurs companies to seek more sustainable practices. Initiatives like minimizing packaging and reducing material use are becoming more common. Some companies are exploring digital health solutions within CBMs, reducing resource utilization.

Adaptability and agility also significantly influence the adoption of CE practices. Complying with stringent regulations and market pressures requires innovative approaches to product design, manufacture, and disposal. Despite the challenges of time-intensive product development, the ability to swiftly adapt to new regulations, market conditions, and technological advancements is often cited as a crucial driver for embracing CE practices. Flexible companies are better positioned to navigate regulatory landscapes and remain competitive in the MedTech industry. A customer-centric approach further enhances the capacity for circularity, highlighting the importance of tailoring solutions to meet customer needs. Agility, exemplified by companies that continuously experiment and adapt to market demands, enables them to stay relevant and responsive, thus maintaining competitiveness and alignment with market dynamics.

Adaptability, agility, and a proactive cultural environment are key to integrating sustainable and CE practices within the MedTech industry. However, increased awareness alone is insufficient without clear evidence of the financial benefits of circularity, indicating a need for supportive measures to realize these practices fully.

7 Discussion

This chapter presents a gap analysis, followed by a discussion of the key findings that contrast these findings with those from the literature review and the case study. Subsequently, interpretations are made, leading to a roadmap for future research. The chapter concludes by discussing research limitations.

7.1 Gap analysis

Factors that are not identified in the literature, but in the case study, and vice versa, are of interest. An overview of the areas identified by the case study, and which were also confirmed by the literature are presented in Table 7.1. Aspects solely presented in the literature represent identified gaps that MedTech companies should consider when adopting CE practices. Additionally, the case companies discussed and highlighted various aspects not previously found in research, to the best of the authors´ knowledge. These identified factors may warrant further investigation in future research.

Table 7.1 The aggregate dimensions found in the case study and how they relate to the theoretical applications found in the literature review.

Aggregate dimension	*Theoretical application*
Regulations	The stringent regulatory environment restricts the recycling options and complicates the adoption of the CE principles. Sustainable practices must be balanced with safety standards (Gonçalves and Franco, 2024; Ishaq et al., 2024).
Technology & Innovation	Technological innovation and adoption are critical in driving the MedTech industry toward sustainable and circular economy practices (Brem et al., 2021; Ishaq et al., 2024).
Financial	High capital investments characterize the MedTech industry and therefore, financial support serves as crucial economic tools (Grafstrom and Aasma, 2021). Some businesses, especially SMEs, often operate with limited resources and may struggle to afford the initial capacity and investment required for adopting and exploring CE practices (Gaberščik et al., 2021; Gonçalves and Franco, 2024; Guzzo et al., 2020).

Stakeholder collaboration	Literature highlights the importance of industry-wide collaboration in fostering circular economy practices in the healthcare sector (Ishaq et al., 2024). The literature further emphasizes the significance of organizational synergy, highlighting the effective alignment and cooperation among different departments and stakeholders. This collaboration is deemed essential for embedding sustainability into the core of BMs. (Rosati et al., 2023).
Market	The market dynamics encompass the forces that shape the business environment directly impacting the implementation of circular economy practices. The literature emphasizes the importance of market engagement to unlock CE opportunities within the healthcare sector (Gaberščik et al., 2021)
Business model	The BM structure significantly influences the adoption of circular economy practices in the MedTech industry. It is critical during the transition to maintain product value in the post-use phase by activating technical cycles (Guzzo et al., 2020; Ishaq et al., 2024).
Organizational	Organizational culture significantly impacts the openness to collaboration and effective internal communication. Dynamic organizational dimensions are vital for encouraging innovation and enhancing adaptability, supporting a sustainable transition within the industry (Assmann et al., 2023; Benz, 2022).

Although Table 7.1 highlights similarities between the findings of the case study and those from the literature review, Table 7.2 below identifies several gaps between them.

Table 7.2 Identified gaps between the case study and previous literature.

Area	*Case study findings*	*Literature review findings*
Global view on regulations	Getting regulatory approval and entering the US market is easier. The FDA determines less strict regulations than the EMA.	The EMA and FDA enforce mandatory requirements for market entry, which impose significant challenges for the integration of CE practices (Akano et al., 2021; Guzzo et al., 2020; Rosati et al., 2023).
Collaborating with regulatory bodies	Collaborating with regulatory bodies to embrace CE practices.	N/a
Aligning policies with SDGs	N/a	Aligning internal policies with the Sustainable Development Goals (SDGs) to unlock innovative sustainability pathways (Awan and Sroufe, 2022; Rosati et al., 2023).
Technological impact	Technological advancements drive the adoption of CE practices in the MedTech industry. A common strategy among companies is to use existing technologies, platforms, and digital channels to enhance their business operations and models.	Enabling technologies like advanced monitoring and measurement tools are crucial for companies to track their progress and optimize their circular economy practices (Benz, 2022).

AI and technological readiness	Developing AI for medical applications may face data security and accuracy. Furthermore, the healthcare sector's readiness to adopt innovative technologies is limited, which challenges MedTech companies to adopt new technologies.	Advanced technology, such as AI is revolutionizing medical device design, manufacturing, and waste management, significantly enhancing resource efficiency (Brem et al., 2021; Ishaq et al., 2024; Rosati et al., 2023).
Integrating technology	N/a	Integrating technologies seamlessly into existing organizational structures presents challenges (Guzzo et al., 2020; Ishaq et al., 2024).
Innovation in material science	Critical need for innovation, particularly in material science, to enable a more circular MedTech industry.	N/a
Changing established BMs	Companies discuss the difficulties in changing established practices and overcoming challenges within traditional BMs that may not readily prioritize circular practices. This resistance to change is often compounded by the need to meet investor expectations and manage the high costs associated with R&D.	N/a
Management role	N/a	The commitment and involvement of top management play a critical role in driving the transition to CE (Benz, 2022; Guldmann and Huulgaard, 2020).
Market	Market incentives are critical for enabling the CE transition in the MedTech industry.	Emphasizes the importance of market engagement to unlock CE opportunities within the healthcare sector (Gaberščik et al., 2021)
Supply chain management	Complexities of implementing CE processes in the supply chain. Collaboration with stakeholders across the supply chain is vital.	The importance of operational supply chain management and its impact on resource efficiency and effectiveness (Benz, 2022; Ishaq et al., 2024; Gaberščik et al., 2021).
Global dispersed value chains	N/a	Globally dispersed and culturally diverse value chains can pose significant challenges for the execution of CE practices (Benz, 2022; Guldmann and Huulgaard, 2020).

The literature often discusses regulatory challenges with a broader geographical perspective, comparing regulations across different countries such as differences

between FDA and EMA standards (Akano et al., 2021; Guzzo et al., 2020; Rosati et al., 2023). This global view must be more evident in the case studies, which focus more on specific regulatory impacts without a comparative international analysis. The case companies highlighted the complexity of obtaining regulatory approval, including CE marking, and the regulatory differences between the FDA and EMA. Companies stated that due to less strict FDA regulations, they prefer to enter the US market over the EU to commercialize as this becomes a quicker way of securing funding. This insight was not explicitly addressed in any previous literature. Unlike the broad regulatory discussions in the literature, case studies specifically mention companies advocating for regulatory changes to support CE practices. This includes direct insights into how companies engage with regulatory bodies to influence policy, a less common perspective in the literature. The companies further suggest collaborating with regulatory bodies to influence regulatory standards to reduce the regulatory barrier and assist the industry in becoming more sustainable. Further, the literature emphasizes aligning internal policies with SDGs to promote sustainable operations (Awan and Sroufe, 2022; Rosati et al., 2023). This alignment is not explicitly mentioned in the case studies, which might overlook the broader context of global sustainability goals.

While the literature and case studies mention technology, the literature tends to delve deeper into specific technologies' potential impacts on circular economy practices. Case studies, however, focus more broadly on technology's enabling role without specifying how these technologies could be harnessed. The case companies also address the risks of integrating AI with medical applications, which the literature does not discuss directly. Further, the companies underscore the healthcare sector's limited readiness to adopt innovation, making it challenging for companies to adopt innovations that may support adopting more sustainable practices. Therefore, there is a need for stronger collaboration between MedTech companies and healthcare providers to ensure a smoother integration of new technologies and innovations. The literature further highlights the difficulty with integrating new technologies into existing organizational structures (Guzzo et al., 2020; Ishaq et al., 2024) which is not directly addressed by the case companies. When discussing innovation, the case companies highlight the importance of innovations to enable CE practices, especially regarding material science. This view on innovation as an important factor is not especially brought up by the literature which indicates another research gap.

Additionally, the companies discussed the difficulties in changing the BM due to investors' expectations and the high cost associated with R&D. The literature also discusses the BMs impact on adopting CE practices. Still, the role of investors is not directly discussed. Instead, the literature explains that the BM structure and the role of top management are crucial for fostering CBMI in businesses (Benz, 2022; Guldmann and Huulgaard, 2020). Further, internal BMI is also presented to play a significant role in driving companies towards continuous practices and fostering a culture of innovation in the company and organizations. The case companies need

to explicitly discuss the concepts of BMI and CBMI, primarily due to a lack of knowledge regarding these areas. The literature further discusses that companies should pay attention to knowledge gaps and lack of knowledge. This may impede the adoption of new practices. The literature underscores that a significant knowledge gap within organizations regarding adopting CE practices further complicates the adoption (Assmann et al., 2023; Gaberščik et al., 2021). The lack of practical knowledge can lead to uncertainties and may result in missed opportunities, exacerbating financial risks.

Another area that was underscored and discussed by the case companies was the role of the market. The interviewees stated that market incentives are critical for the MedTech industry to adopt CE practices. They present that there is a particular need for incentives from larger industry players or authorities to create an industry-wide shift as SMEs struggle due to constrained resources. This insight is not especially highlighted in literature. Instead, the literature emphasizes the importance of market engagement to unlock CE opportunities within the industry (Gaberščik et al., 2021). Furthermore, the literature revealed that there is a stakeholder resistance due to a strong linear economy mindset in the industry and the lack of economic incentives for circularity (Grafstrom and Aasma, 2021; Vermunt et al., 2019). These aspects were not specifically addressed by the interviewees, however they underscored the importance of continuous market analysis of emerging research and technologies to respond and adapt to trends and advancements that may facilitate the adoption of CE practices.

Supply chain management is another area that is briefly addressed by the case companies but is discussed more in depth by the literature. Overall, the interviewees brought attention to the complexities with implementing CE practices in the supply chain and collaborating with stakeholders across the supply chain is vital to create a supportive environment. Research, however, further underscores the importance of supply chain management and its impact on resource efficiency and effectiveness (Benz, 2022; Ishaq et al., 2024; Gaberščik et al., 2021). There are various challenges with integrating CE practices into existing processes and supply chains and therefore effective management and strategic collaboration is vital for overcoming these challenges.

Various CE practices require implementing efficient reverse logistics and rely on the supply chain's ability to manage globally dispersed and culturally diverse value chains, where a lack of knowledge can pose significant challenges for the execution (Benz, 2022; Guldmann and Huulgaard, 2020). The literature discusses the complexity of global value chains and CE practices. In addition to potential knowledge gaps, more dispersed supply chains make it more difficult for companies to adopt CE practices as more influencing factors are added than if the supply chain would be more local. This aspect is not specifically addressed by any company.

There could be various reasons to why there are discrepancies between the literature and the case study. A reason could be that the literature broadly explains factors that

may affect the adoption of CE practices that are not necessarily always applicable to the MedTech industry. The companies, however, explicitly explain in more detail what areas may affect the adoption according to their conditions in the industry. The literature often gives a general picture of various factors that influence adoption, but the reality is often more complex, as presented by the interviewees. Another reason for the discrepancies is the familiarity and knowledge gap among the case companies regarding the concept CE practices, which may not give full insight into all the factors that could influence the adoption.

7.2 Interpretations and recommendations

The transition toward a CE in the MedTech industry is driven by a tightly interconnected network of factors, as illustrated in Figure 7.1: regulatory frameworks, technological advancements, financial incentives, market dynamics, supply chain management, business models, and organizational culture. The literature review explores these elements, while case studies based on interviews with MedTech companies provide practical insights into their application. These studies bridge the gap between theory and practice, enhancing understanding of the dynamics influencing adoption. By integrating these insights, a roadmap can be developed that outlines practical steps for companies to innovate and adapt, ultimately facilitating a transition to more sustainable BMs.

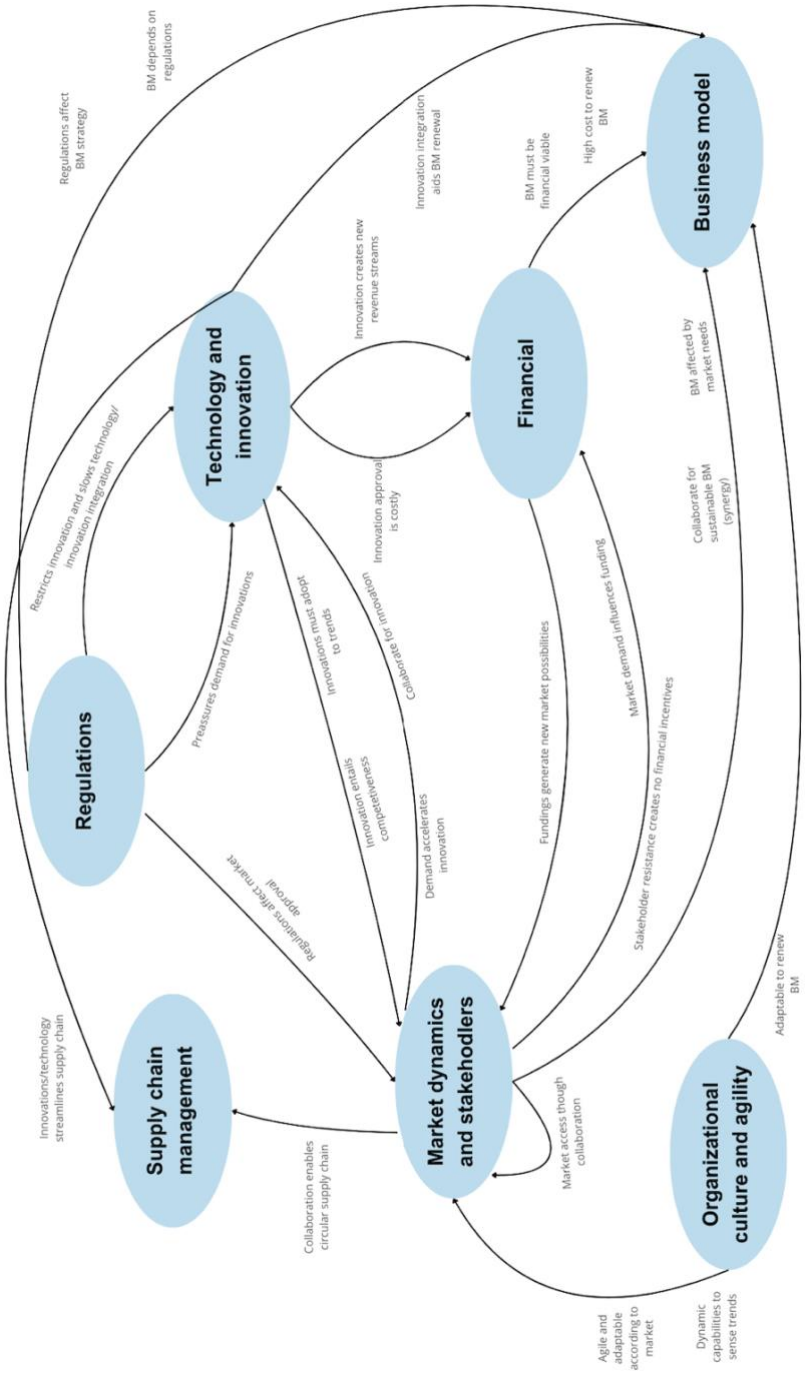

Figure 7.1 The correlation between key factors influencing the adoption of circular economy practices.

The literature and case study indicate that the MedTech industry, one of the most heavily regulated globally, faces specific challenges in adopting CE practices primarily due to strict regulations prioritizing patient safety and risk management. These regulations, enforced by bodies like the FDA and EMA, ensure safety and efficacy but also restrict recycling and reprocessing activities, posing substantial barriers to sustainable innovation. Companies report that strict safety and sterility requirements greatly restrict their recycling and reuse initiatives. This regulatory rigidity often conflicts directly with the objectives of a CE, where materials are meant to be recycled or reused to reduce waste. Additionally, the literature highlights current regulatory frameworks hinder the reuse and reprocessing of medical devices, underscoring the necessity for regulatory innovation that balances safety with sustainability. In alignment, economic incentives and supportive regulations are crucial for enabling circularity in the healthcare sector, emphasizing the need for a shift in regulatory approaches. The case study describes the regulatory approval process as time-consuming, costly, and complex. It slows innovation and shifts resources towards compliance rather than sustainable practices. However, it emerged that the FDA has less stringent regulations than the EMA, making it more accessible to get approval and enter the US market. The difference in regulatory flexibility between bodies like the FDA and the EU demonstrates that achieving a balance that promotes safety and sustainability is feasible. Additionally, both literature and case studies underscored that enhanced stakeholder engagement would drive these regulatory changes, aligning with both environmental imperatives and the evolving nature of MedTech products.

The MedTech industry and its products heavily rely on technological advancements, highlighting the critical role of advanced technologies such as AI and material sciences in enhancing sustainability. These technologies are crucial for sustainability. They enhance product and process efficiency by enabling recycling, reuse, and material reduction. However, the literature and case studies both indicate challenges in integrating these technologies due to compatibility issues with existing systems, limited market demand, and stringent regulatory compliance requirements. Case studies particularly underscore that while companies are keen to leverage new technologies to enhance operational efficiency and extend product life cycles through better design and manufacturing practices, several barriers hinder these efforts. These include high costs and technical difficulties in meeting health standards for reprocessed equipment, the need for investment, and the complexities of the approval processes. The healthcare sector's limited readiness to adopt these innovations and the lack of direct incentives further complicate the situation. In alignment, literature underscores the need for companies to reconsider their entire product life cycles, from design to disposal and waste management, to integrate circularity fundamentally. Findings from the case studies, however, underscored the challenge in managing the supply chain to support these considerations. This underscores the difficulties in integrating CE practices into existing supply chains and notes the importance of strategic partnerships and collaborations.

Strategic management and effective partnerships are essential for optimizing resource use and managing reverse logistics, particularly in culturally diverse and globally dispersed value chains. Despite these challenges, companies recognize the potential within the industry to harness this potential to facilitate CE practices. Strong collaboration between MedTech companies and healthcare providers is seen as essential for overcoming these barriers. However, as stated by one participant, it is also important to note the challenge of maintaining confidentiality and keeping certain information within the company. Moreover, the industry's capacity for innovation is viewed as a key driver for producing and delivering products with longer lifespans and greater recyclability through the integration of advanced technologies. This approach not only meets environmental objectives but also responds effectively to increasing regulatory demands for sustainable healthcare solutions.

Financial incentives greatly affect companies. High costs related to R&D, compliance, and market entry present major barriers. Case studies reveal that although CE practices can eventually lead to cost savings and efficiencies, the initial financing and risk associated with new technologies and processes are often prohibited. The challenge of securing funding further complicates efforts toward sustainable practices. Many companies rely on external capital, prioritizing immediate financial returns over long-term sustainability, complicating the adoption of CE practices. Therefore, funding and financial incentives are crucial for driving the circular transition in the MedTech industry. Moreover, financial incentives and investments enable MedTech companies to adopt CE practices. These incentives address significant initial costs and financial risks for new technologies and processes. By offering financial support and tax incentives, governments and financial institutions can lessen the financial burden on companies, especially SMEs, facilitating innovation without the immediate pressure of financial returns. This support not only eases the transition but also can shift market dynamics significantly by making it economically beneficial for companies to adopt CE practices, potentially leading to widespread adoption and the establishment of new industry standards.

The literature emphasizes how market dynamics and stakeholder resistance complicate the adoption of CE practices. Traditional linear economic models, stakeholder reluctance create a conflicting environment that challenges the adoption. The case companies strengthen this statement, highlighting limited market demand as a primary reason why companies hesitate to pursue more circular options. Due to a lack of demand from stakeholders and insufficient market demands, companies have been slow to adopt CE practices. Despite these barriers, interviews reveal a growing interest and awareness among stakeholders of the potential benefits of circularity. However, the absence of evidence and comprehensive studies is the reason for the lower prioritization of CE practices among MedTech companies. The case studies suggest that engaging with stakeholders and educating them about the benefits of CE practices are essential for

creating a market environment more conducive to sustainability. Effective market engagement and stakeholder collaboration, including industry players, healthcare providers, and regulatory bodies, is therefore necessary for advancing CE practices. These efforts are particularly valuable as they develop standards, create opportunities, and reduce market entry risks, offering a more supportive ecosystem.

Incorporating CE practices into BMs is pivotal for the long-term sustainability of the MedTech industry. The literature advocates for reevaluating product designs, production processes, and overall business strategies to enhance circularity. It also highlights the importance of internal communication, utilizing frameworks such as the BMC to navigate the complexities of adopting CBMIs effectively. Despite the industry's hesitance and need for explicit renewal of strategies, a few companies are in the growth and maturity phase, and express that they are actively seeking to explore various approaches to innovating business strategies. They demonstrated that they are more likely to align with CE practices in the future, underlining the lack of resources for such practices today. Among these companies, it was made clear that to become more circular in their operations, there is a need for greater awareness, regulatory alignment, financial support, and consumer demand to drive the industry's widespread adoption of CE practices.

Additionally, efficient supply chain management that integrates CE practices is also crucial. The literature emphasizes how it not only ensures the quality and availability of recycled materials necessary for producing safe and reliable MDs, but also supports corporate social responsibility goals. Such strategic management is vital for ensuring long-term resource availability and stability. Furthermore, as previously stated, advancements in logistics are essential for the effective implementation of these principles, enhancing the feasibility of embedding circularity within the supply chain. Additionally, the literature advocates that fostering a company culture that supports openness, innovation, and continuous dialogue is crucial for adopting CE practices. Such a culture enables organizations to adapt and embrace change readily and innovate effectively, aligning with global sustainability trends and regulations. It encourages a proactive approach to innovation, essential for integrating CE principles, which often require new ways of thinking and operating.

7.2.1 Implications: Roadmap

Looking forward, the intersection of regulatory compliance and environmental sustainability will likely drive the future of MedTech innovation. As the industry progresses, fostering an environment that not only adheres to stringent safety regulations but also embraces the principles of circularity will be essential. This involves rethinking how devices are designed, manufactured, and disposed of, ensuring that sustainability becomes an integral part of the lifecycle of medical products. Emphasizing the development of policies that support these dual

objectives will be crucial for the long-term success of the CE in the healthcare sector. Such strategies will mitigate the environmental impact and align with the evolving regulatory landscape that seeks to balance patient safety with environmental concerns.

Building on the theoretical and practical insights discussed earlier, it is crucial to translate these findings into actionable steps for MedTech companies. The roadmap is designed to guide MedTech companies through the complex landscape of adopting CE practices, drawing from the research questions and the interconnected areas detailed in previous sections, see Figure 7.2. It has been designed and developed by evaluating the various factors and their implications and matching them to the market development phases: introduction, growth, and maturity. As the development phase affects the companies' ability to innovate, it may also impact their conditions regarding whether they can adopt CE practices, CBM, or CBMI. This roadmap lays out actions tailored to the development phases and addresses various factors influencing CE practices among MedTech companies.

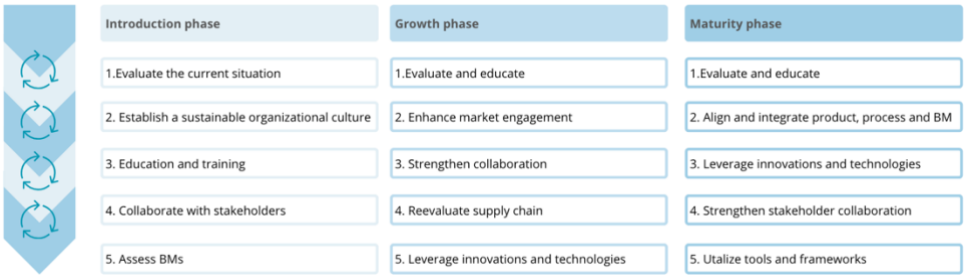

Figure 7.2 Roadmap for the different development phases.

Roadmap – Introduction phase

In the introduction phase, companies focus on product innovation. It is essential to consider circularity at this stage, as integrating circular principles early on will make their adoption easier once companies reach the maturity phase. While primarily focusing on product innovation, companies should investigate how their products can become more circular. At this phase, companies are in early market development, typically experiencing low industry sales and limited financial resources. Therefore, they should prioritize enhancing organizational culture, knowledge, collaboration, and BMs, which often require minimal financing.

First, companies should evaluate their current situation by examining their products, processes, and BMs. They are strongly encouraged to explore integrating circularity into their businesses by embedding technical cycles such as reuse, reduce, remanufacture, and recycle. This approach aims to design and manufacture products that are easier to disassemble, repair, and recycle. For example, designing for modularity or using simpler materials can significantly contribute to circularity.

Adopting this mindset can also inspire companies to establish take-back programs, facilitating the refurbishment, recycling, or responsible disposal of used products,

thereby closing the product lifecycle loop. Additionally, companies should assess their current market position if they have already entered the market and analyze competitors for inspiration and potential development opportunities.

Establishing a sustainable organizational culture is crucial for adopting circularity within a business. This requires embedding circular principles into both company culture and internal policies. Aligning these policies with the Sustainable Development Goals (SDGs) will directly promote more sustainable operations. The company's culture and its attitude toward circularity set the standard for its approach to sustainability.

Implementing circular-focused training programs that increase awareness and close the knowledge gap is important to foster a culture of circular thinking. Personnel should be aligned with the company's sustainability goals, and knowledge about sustainability and circularity should be disseminated widely.

In this phase, companies should also prioritize stakeholder collaboration. Engaging with healthcare providers, academic institutions, regulatory bodies, and other market players is essential to access support and facilitate the exchange of knowledge and best practices across the industry. Collaborating with academic and regulatory bodies fosters innovation and helps navigate stringent regulations, ensuring that theoretical advancements are applicable and meet real-world needs.

Finally, companies in the introduction phase should assess their BMs. They need to evaluate potential CBMs and determine which ones could be the best fit. Using a trade-off matrix, illustrated in Figure 4.7, can help identify the most appropriate CBMs for their products and guide innovation and development efforts. For example, high-value, non-critical devices are prime candidates for refurbishment, so companies should design these products for easier refurbishment.

Roadmap – Growth phase

In the growth phase, companies shift their focus to process innovation. As industry sales increase, financial constraints lessen, allowing companies to concentrate on making their processes more circular. To achieve this, companies should enhance their market engagement, stakeholder collaboration, and supply chain efficiency.

Like the introduction phase, companies should begin by evaluating their current products, processes, and BMs to identify opportunities for implementing CE practices. Changes in technology, innovations, or stakeholder dynamics since the introduction phase may necessitate new approaches. Continuous education for personnel is also crucial to maintain awareness and close the knowledge gap.

With increased industry sales during the growth phase, enhancing market engagement becomes vital. Effective market engagement improves interaction with customers and stakeholders, spreading awareness of circular initiatives and reducing potential resistance due to lack of knowledge. Staying updated with current trends enables companies to adapt their products and leverage new innovations.

Strengthening collaboration with academic institutions and the healthcare sector fosters innovation and promotes CE practices. Early communication with the healthcare sector helps identify potential limitations in circular products and processes, allowing for timely adjustments that facilitate adoption.

Additionally, companies should reevaluate their supply chain before reaching maturity, when industry sales and production levels peak. Incorporating reverse logistics and reassessing the BM can streamline processes to better fit CE practices. Evaluating the supply chain helps companies understand the value chain and collaborate effectively with different stakeholders.

Leveraging innovations and technologies is essential for making processes more circular. Companies should continuously reevaluate their BMs, considering how technological upgrades, regulatory changes, or market dynamics have shifted their products within the trade-off matrix, illustrated in Figure 4.7. By understanding where products fall in the matrix, companies can plan and adjust their processes to align with recommended circular strategies.

Roadmap – Maturity phase

In the maturity phase, companies focus on business model innovation. At this stage, companies should explore how to make their business models more circular. For MedTech companies, fully integrating circular principles into their operations during the maturity phase is crucial. With industry sales at their peak, companies can concentrate on reinventing and improving their BMs.

During the maturity phase, companies should leverage innovations and technologies, strengthen stakeholder collaboration, and utilize tools and frameworks to enhance the circularity of their BMs.

As in the growth phase, companies should start by evaluating their current products, processes, and BMs to match the current situation and continue education initiatives to close the knowledge gap. It is advisable for companies to thoroughly reevaluate their products, processes, and BMs to ensure alignment with CE principles. Leveraging existing and new technologies to enhance circularity and exploring new market opportunities that align with these practices are crucial for maintaining competitiveness. Adapting to current market trends in technology and innovation, as well as exploring new market opportunities, helps companies stay competitive.

Ongoing stakeholder collaboration is essential to navigate the challenges and opportunities of a more integrated circular approach in an evolving landscape. Companies should focus on maintaining and strengthening their collaboration with stakeholders, who play a pivotal role in the adoption process.

Finally, in the final stage of adopting CBMs and CBMI, companies should utilize tools, frameworks, and methodologies that support the reinvention of business practices. The trade-off matrix is recommended for MedTech companies to evaluate which CBM and associated circular strategy to adopt. If this has not been done

during the introduction and growth phases, companies should consider adopting this framework now to integrate circular principles as comprehensively as possible. The matrix requires continuous reassessment to keep pace with technological advancements and market changes. Additionally, the product’s value and criticality must be reevaluated as market and regulatory conditions evolve.

These recommendations and strategies are designed to help MedTech companies adopt circular business practices. By embracing these guidelines, companies and stakeholders across the MedTech industry can significantly reduce their environmental footprint. Regardless of a company's stage in the market development phase, there is always a compelling reason to start thinking more circularly and adopting CE practices. Doing so benefits not only the environment but also enhances the company's sustainability and competitiveness.

The general roadmap

The steps for the roadmap have been further compiled, with the steps for each development phase merged, from the introduction phase to maturity. These steps are illustrated in Figure 7.3 and provide an overview of the actions required to implement circularity, from start to finish.

Figure 7.3 The general roadmap for MedTech companies towards circularity.

7.3 Research limitations

Despite its advancements, this research has significant limitations that must be acknowledged. The findings, derived from a small sample of Swedish MedTech companies, may not reflect broader industry dynamics. Most of these companies are in their introductory or growth phases and may not yet fully adopt or have implemented business model innovation and circular economy practices. Consequently, their responses could thus be speculative rather than based on practiced experience, challenging the representativeness of the data.

Moreover, as these companies are concentrated within the Stockholm and Skåne

regions, the geographic specificity may further limit the generalizability of the results. The insights are particular to a segment of the MedTech industry, shaped by the local market conditions and regulations in the Stockholm and Skåne regions.

The frameworks and strategies discussed may not capture all nuances of the MedTech industry. Certain assumptions made for generalizability might not hold across different market or regulatory environments, which restricts the applicability of the suggested strategies. Additionally, the proposed roadmap for integrating circular economy practices has not been tested, limiting our ability to evaluate its effectiveness due to research time constraints.

For future research, it would be beneficial to expand the study to include a broader range of companies varying in size, maturity, and geographical location. This diversification would foster a more comprehensive understanding of how MedTech companies integrate CE practices into their BMs. This would also provide more varied data from which to draw conclusions. Further research should focus on testing and extending framework to specific types of medical devices and operational contexts, thereby broadening its applicability and contributing to global environmental and economic sustainability goals.

8 Conclusion

This chapter presents the study's conclusions, directly addressing the research questions that guided the study and briefly introducing the roadmap. Following the conclusions, the implications for future research are discussed, highlighting potential areas for further investigation and development.

This study examines how Swedish companies integrate environmental and economic sustainability into their BMs, specifically focusing on adopting CBMs. The comprehensive literature review and case study led to key findings in the conclusions below. Given the interconnected nature of the concepts in question, the factors identified influence all three investigated areas: adopting CE practices, CBMs, and CBMI. However, certain factors uniquely impact CBM and CBMI. These unique influences are detailed further in the discussion.

8.1 Concluding results

RQ1) What key drivers and barriers within the MedTech industry influence the adoption of circular economy practices?

The most significant drivers include technological advancements that enable resource efficiency and lifecycle management, regulatory incentives that promote sustainability, increasing demand from market and stakeholders for environmentally friendly products, and economic benefits associated with reduced resource use and waste. However, barriers also persist, notably the stringent regulatory environment that can limit the flexibility required to implement CE practices, the high initial costs and investment risks associated with transitioning to new business models, and a lack of infrastructure for executing circular processes such as recycling and reusing medical devices.

RQ2) What key factors influence the successful adoption of circular business models in MedTech companies?

Several factors significantly influence the successful adoption of circular business models in MedTech companies. Organizational agility and a culture that fosters innovation and responsiveness to change are crucial. Supportive regulatory frameworks that recognize and incentivize sustainable practices can accelerate adoption. Additionally, the integration of CE practices into core business strategies,

supported by investments in technology and process innovation, ensures these models are both sustainable and economically viable. Moreover, stakeholder engagement, including customers, suppliers, and regulatory bodies, is vital in developing and sustaining these BMs.

RQ3 a) What key factors influence the adoption of circular business model innovation?

Adopting circular business model innovation is driven by the need to align with global sustainability trends and respond to market and regulatory pressures. Factors such as strong leadership commitment to sustainability goals, the availability of technological resources to enable circular processes, and well-informed personnel capable of driving and managing change are critical. The readiness to reconfigure supply chain operations to accommodate recycling and reusing activities also plays a decisive role.

RQ3 b) How do MedTech companies employ circular business model innovation?

All the participants stated that they do not explicitly engage in specific CE practices. After evaluating these findings, it emerged that most of the companies are in the introduction/growth phase, indicating that they do not yet focus on circular business model innovation. The more established companies were not familiar with the concept of CBMI or did not have an explicit process for BMI, despite their placement in the maturity phase. This finding highlights a significant knowledge gap and underscores the necessity of enhancing awareness about CE practices to foster a transition towards circularity within the MedTech industry.

The roadmap

Based on the literature and case study findings, a roadmap has been developed to guide MedTech companies in adopting CE practices. This roadmap is based on the companies' development phase and considers the various factors influencing the adoption of CE practices among MedTech companies. Figure 7.3 in Chapter 7 shows an overview of the roadmap. By embracing these recommendations, companies, and stakeholders across the MedTech industry can reduce their environmental footprint while positioning themselves as leaders in a future where circularity will likely be a market standard rather than an exception. These actionable steps are not just recommendations but essential strategies for future resilience and growth in an increasingly resource-constrained world. Continuing research and collaborative efforts will be crucial in refining these practices and overcoming the challenges that arise during their implementation.

8.2 Future research

The findings of this thesis, while providing valuable insights into the adoption of

CBMs in the MedTech industry, highlight significant areas for future research due to certain inherent limitations. A critical limitation of this research is its reliance on existing literature and case studies specific to the MedTech industry, which may not encompass the full spectrum of challenges and opportunities in varied market conditions. Consequently, the findings may not be universally applicable, especially in regions or sectors with unique regulatory, economic, or cultural characteristics not extensively covered in the study.

Given the reliance on literature and case studies specific to the MedTech industry, future research should broaden the geographical and sectoral scope of study. Investigating CBM practices in diverse market conditions and under different regulatory, economic, and cultural frameworks can enhance the generalizability of the findings. This expanded approach would help understand how CBMs can be adapted or modified for successful implementation in varied global contexts.

The predominantly conceptual nature of the frameworks discussed in this thesis underscores the need for empirical research. Future studies should focus on conducting practical experiments and studies to validate and refine these models. By testing these frameworks in real-world settings, researchers can identify potential adjustments and improve the practical applicability of CBM and CBMI strategies in the MedTech industry.

There is a clear lack of awareness and practical implementation of CBMs among MedTech companies. Subsequent research could explore the barriers to awareness and adoption of CBM and CBMI. Investigating educational and communicational strategies that could increase understanding and implementation of CE practices within the industry would be valuable. This could include the development of training modules, workshops, or case study analyses that demonstrate the economic and environmental benefits of adopting circular models.

Conducting longitudinal studies to track the long-term impacts of CBM adoption on company performance and sustainability metrics would be beneficial. These studies could provide deeper insights into the effectiveness of CE practices over time and offer a more comprehensive understanding of the dynamic interplay between circular business strategies and industry evolution.

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Appendix A Literature review

Appendix A contains a detailed table summarizing the 21 selected articles from the last compilation of the literature review.

A.1 Selected articles from the literature review

Table A.1 Overview of the 21 selected articles from the literature review.

Author (year)	*Title*	*Keywords*	*Summary/Notes*
Akano, D.I.; Ijomah, W.; Windmill, J. (2021)	Hierarchical analysis of factors influencing acceptance of remanufactured medical devices	Remanufacturing, Medical devices, Sustainability	- Key barriers in the acquisition, remanufacturing process steps, and selling remanufactured medical devices - Key consumer factors influencing the acceptance of medical devices
Aasma, S.; Grafstrom, J. (2021)	Breaking circular economy barriers	Circular economy, Barriers, Sustainability, Recycling	- Examines four types of barriers to implementing CE - Model illustrating barriers and their inter-dependencies
Assmann, I.R.; Rosati, F.; Marioka, S.N. (2023)	Determinants of circular business model adoption—A systematic literature review	Missing	- Presents determinants of CBM adoption - Classifies 54 determinants into eight categories - Determinants serve as drivers and barriers to adopting CBM
Awan, U.; Sroufe, R. (2022)	Sustainability in the Circular Economy: Insights and Dynamics of	Circular economy, sustainability, business model, Circular economy business models	- Critical success factors for implementing CBMI - A conceptual model is developed to identify

	Designing Circular Business Models		success factors in adopting CE practices
Balkkenende. R; Carvalho M.M; Guzzo. D; Mascarenhas. J (2020)	Circular business models in the medical device industry: paths towards sustainable healthcare	Medical device industry, Circular business models, Circular economy, Innovation	- Various MD companies apply CE strategies - Circular strategies application differs based on MD value and criticality - Nine types of CBM exist in MD industry - CBM can assist in identifying innovation opportunities
Benz, L. A. (2022)	Critical Success Factors for Circular Business Model Innovation from the Perspective of the Sustainable Development Goals	Circular economy, SDG:s, Innovation	- Investigates critical success factors for CBMI - Findings are divided into internal and external perspectives
Boyer, R.H.; Diener, D.; Hollander, M.D.; Nyström, T.; Whalen, K.A. (2021)	Managing Circular Business Model Uncertainties with Future Adaptive Design	Circular economy, Circular business model innovation	- Presents challenges in CBM which include premature obsolescence - Future adaptive design strategies are presented - A conceptual framework for future adaptive design strategy for CBM is presented
Fayne, A.; Gaberščik, C.; Mitchell, S.; Scholz, S. G.; Howlett, R. J.; Setchi, R. (2021)	Saving lives and saving the planet: the readiness of Irelands healthcare manufacturing sector for the circular economy	Missing	- Drivers, motivators, and barriers of CE in healthcare manufacturing
Franco, M.; Goncalves, A. (2024)	Health product innovation and circular economy: A case study of inter-organisational cooperation in the development of a new firm	Circular economy, Innovation, Sustainability	- Barries to transition to circular economy models are presented - Studies the dynamics of cooperation in the health field and how it can lead to sustainable product innovation
Gassmann, O.; Neumann, L.;	Business Models for Frugal Innovation in Emerging Markets_	Missing	- Investigate business models for frugal innovation within medical

Winterhalter, S.; Zeschky, M.B. (2017)	The Case of the Medical Device and Laboratory Equipment Industry		and laboratory equipment industry - Two R&D strategies for the development of frugal business models are presented
Guldmann, E.; Huulgaard, R.D. (2020)	Barriers to circular business model innovation: A multiple-case study	Circular economy, Circular business models, Circular business model innovation, Barriers	- Investigate barriers to CBMI - An overview of challenges of adopting CBM is presented
Ishaq, S.; Hoang, T. G.; Truong, H. Q. (2024)	Transformative capabilities of MedTech organizations in driving circularity in the healthcare industry: Insights from multiple cases	Circular economy, MedTech, Healthcare industry, Sustainability	- Explores how MedTech companies adopt circular practices - Findings include different strategies MedTech companies adopt categorized in sensing, seizing, transforming and adaptability/flexibility - Framework for promoting circularity in MedTehc is presented
Lewandowski, M. (2016)	Designing the Business Models for Circular Economy—Towards the Conceptual Framework	Business models, Circular economy, Circular business model, Sustainable business model	- Conseptucal framework for circula business models supporting the transition from lineat to circular model is presented - Poposes a circular business model canvas (CBMC)
McDermott, O.; Antony, J.; Sony, M.; Healy, T. (2022)	Critical failure factors for continuous improvement methodologies in the Irish Medtech industry	Medical device, MedTech	- Identifies critical sucess factors and barriers for continues improvement (CI) in the MedTech industry
Nussholz, J. (2017)	Circular business model framework: mapping value creation architectures along the product lifecycle	Circular economy, Circular business model, Business model innovation	- Presents a CBM framework to guide the development of CBM that capitalize on cycling resources
Rosati. F; Rodrigues. V.P;	Business model innovation for the	Missing	- Six phase approach to conduct BMI for the SDGs

Cosenz. F; Li-Ying. J (2022)	Sustainable Development Goals		- Helps integrating SDG perspective into BMI
Singh, R.; Khan, S.; Dsilva, J. (2022)	A framework for assessment of critical factor for circular economy practice implementation	Circular economy, critical factors	- Identifies 15 critical factors influencing the adoption of circular economy practices
Sinha, E. (2022)	Circular economy—A way forward to Sustainable Development: Identifying Conceptual Overlaps and Contingency Factors at the Microlevel	Circular business, Circular economy	- Presents a framework that identifies barriers at the micro level and discusses eight barriers to circular business processes
Tan, J.; Tan, F. J.; Ramakrishna, S. (2022)	Transitioning to a Circular Economy: A Systematic Review of Its Drivers and Barriers	Circular economy, Sustainability, Drivers, Barriers	- Identified drivers and barriers affecting the adoption of circular economy practices
Tran-Thi-Thanh, T.; Nguyen-Thi-Phuong, A. (2022)	Exploring the Mechanisms Underlying Firms' Intent to Adopt Circular Business Models	Circular business model, Circular economy	- Explores factors influencing the adoption of CBMs
Vermunt, D.A; Negro S.O.; Verweij P.A.; Kuppens, D.V., Hekkert M.P. (2019)	Exploring barriers to implementing different circular business models	Circular business model, Implementation barriers	- Presents different barriers to CBM implementation - Explores and compares barriers between different business models

Appendix B Interview information

Appendix B contains detailed interview information, including a list of interviews and interviewees, the interview guide and the PowerPoint presentation utilized during the interviews.

B.1 List of interviews

Table B.1 List of interviews

Case Company	*Headquarters*	*Founded year*	*Date & Duration*	*Format/Place*
MC1	Chief executive officer	2014	12 March 2024, 09:00-09:45	Interview via Zoom
MC2	Chief executive officer	2015	12 March 2024, 15:30-16:20	Interview via Zoom
MC3	Chief executive officer, Co-founder	2020	15 March 2024, 13:15-14:00	Interview via Zoom
MC4	Chief executive officer	2013	19 March 2024, 08:00-08:45	Interview via Zoom
MC5	Chief technology officer	2006	21 March 2024, 09:00-10:00	Interview at Medicon Village
MC6	Chief executive officer	2018	22 March 2024, 09:00-10:00	Interview via Zoom
MC7	Chief operations officer	2010	26 March 2024, 10:00-11:00	Interview via Zoom
MC8	Chief executive officer	1999	27 March 2024, 11:00-11:35	Interview via Zoom
MC9	Chief executive officer	2000	27 March 2024, 15:00-15:30	Interview via Zoom Completion via email

B.2 Interview guide

Preparations:

- Background about the company
    - Sustainability goals
    - Company vision and mission/ goals
- Background about the interviewee
- Timeplan and strategy for the interview

Part 1: Introduction & Purpose with Interview

- *Brief presentation of the authors and the thesis, along with the research questions*
- Okay to record this interview?
    - Who will be asking questions and who will take notes

Part 2: Background about [THE COMPANY]

- Please tell us about yourself and your role in [THE COMPANY]?
- Can you briefly explain [THE COMPANY]?
    - Do you have any other documents or papers regarding company info except from the website?
        - Could you maybe share this with us?
    - To get a better overview of the company
    - Ex. Size and age, type of technologies/ innovations
- Which category of MedTech do you have? And what classification do you have?
    - Medical Devices (MD)
    - In Vitro Diagnostics (IVD)
    - Digital health solutions

Part 3: Business model

- *Introduce the concept of the Business model*
    - *Present a figure*
    - *Value proposition, interface, business structure, revenue model*
- Based on this concept of a business model, what does [THE COMPANY]'s current business model look like?
    - Let them explain their business model!
    - To understand their current BM
    - Ex; B2B/B2C, service or physical product..?

Part 4: Circular Business Models

- *Introduce the concept of CBM*
    - *Present the 4 categories of CBM*
- Based on this concept of a circular business model, how does [THE COMPANY] work with circularity?
    - Have you considered implementing circular business models?
        - NO/YES: Why? Please elaborate.
- Have you noticed any critical junctures for implementing circular business models for your [THE COMPANY]? And to become more circular?
    - What barriers have you identified?
        - (Laws and legislation?)
    - What drivers have you identified?
        - (The network and collaboration in the industry?)
    - … and for the MedTech industry in general?
- What would you believe to be needed for these barriers to be overcome?
    - What laws/legislations, stakeholders impact, and who needs to be involved?
- CBM for Medical device company + IVD:
- *Introduce the matrix and describe the axes*
    - Could you place [THE COMPANY] in the matrix? Where and why?
    - What CBM do you think would fit your company?
        - Based on the *4 categories of CBM*

Part 5: Business Model Innovation

- How does [THE COMPANY] renew its business model?
    - What resources do you have for this?
    - To understand how they work with BMI
    - Do they use any tools or frameworks?

Part 6: Barriers and Drivers

- What barriers and drivers have you encountered in the MedTech industry?
- What have you noticed being critical success factors for your [THE COMPANY] in the MedTech industry?
- Have you had any challenges that have affected/influenced the development of your [THE COMPANY]?

Part 7: Future

- What are the next steps for [THE COMPANY]?
- What are [THE COMPANY]'s future goals?
    - Any sustainability goals?

Part 8: Conclusion

- Would you like to add anything?
- Would it be okay to come back with more questions by mail if that would be necessary?
- The report will be of "public" (offentlig handling); is it okay to use the company name in the study or would you like to be anonymized?
- We will share the thesis and our findings with you at the end of May/beginning of June
- Thank you for your participation and your input!

B.3 PowerPoint presentation for interviews

PowerPoint presentation used during the interview

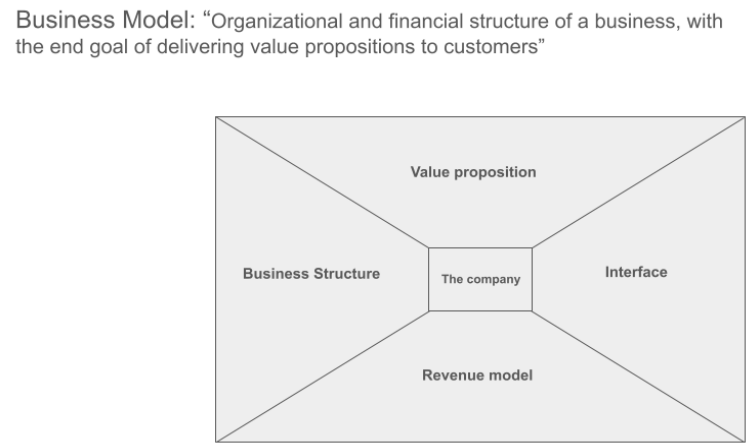

Figure B.1 First PowerPoint presentation slide.

Circular business models: Business models that are cycling, extending, intensifying, and/or dematerialising material and energy loops

4 strategies:
- Cycling
- Extending
- Intensifying
- Dematerialisering

Figure B.2 Second PowerPoint presentation slide.

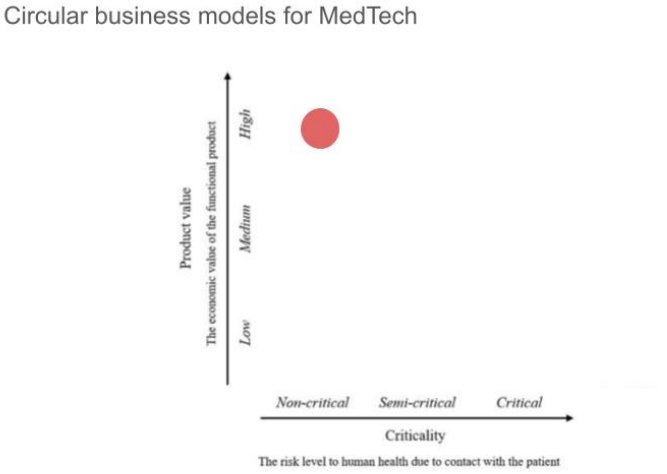

Figure B.3 Third PowerPoint presentation slide.

Appendix C Theoretical framework

Appendix X contains a summarizing table presenting different circular business model subcategories.

C.1 Circular business models strategy and subcategories

Table C.1 Circular business models strategy and subcategories based on previous research.

CBM strategy	***Purpose***	***CBM subcategories***	***Description***
Cycling	Strategies focus on recycling materials and energy within the system to maintain functionality and reduce waste (Geissdoerfer et al., 2020).	Closed loop recycling	Using recycled products as raw materials to manufacture new products (Forum for Future, 2018)
		Downcycling	Turning materials from one or more used products into a new product with lower quality (Forum for Future, 2018)
		Upcycling	Turning materials from one or more used products into new products, implying an improvement in quality (Forum for Future, 2018)
		Industrial symbiosis	Sharing services, utilities, and by-products among industries to improve resource efficiency (Colombo et al., 2021;Forum for Future, 2018; Pieroni et al., 2020; Woldeyes et al., 2023)
		Collection services	Providing a service to collect old or used products (Forum for Future, 2018)
		Local loop	(Forum for Future, 2018)
		Recycling	Transform waste into raw materials for manufacturing new products (Colombo et al., 2021; Woldeyes et al., 2023)
		Organic feedstock	Using biomass as an input for production processes, thus closing the resource loop. (Colombo et al., 2021)

		Resource efficiency	Optimize the use of virgin material and the consumption of other resources during the production phase. (Colombo et al., 2021)
		Product on demand	Produce only if there is demand and the if the products have already been ordered. (Colombo et al., 2021; Pieroni et al., 2020; Woldeyes et al., 2023)
		Renewable sources	Use renewable sources to reduce the greenhouse gas emission. (Colombo et al., 2021; Woldeyes et al., 2023)
		Remanufacturing	Remanufacture or refurbish products. (Colombo et al., 2021; Woldeyes et al., 2023)
		Reuse	Resell or reuse product without repairs or upgrades. (Colombo et al., 2021; Pieroni et al., 2020; Woldeyes et al., 2023)
		Take back & reprocessing use products	Cooperation in the production value chain leading to closing material loops. (Pieroni et al., 2020)
		Cleaner production and eco-efficiency	Waste, pollution and energy consumption reduction in production process. (Pieroni et al., 2020)
		Source circular supplies	Sourcing circular products or materials. (Pieroni et al., 2020)
		Asset management	Optimizing companies´ own assets by pooling, sharing, lending, re-using, refurbishing, or re-selling. (Pieroni et al., 2020)
		Bio-/secondary materials	Enviromentally sustainable material usage. Designing product to use waste as input and circular products or materials. (Woldeyes et al., 2023)
		Resource and energy efficiency	Waste reduction activities and minimizing energy consumption. (Woldeyes et al., 2023)
		Energy recovery	Recovering energy out of waste materials. (Woldeyes et al., 2023)
		Incentivized return	Incentivizing customers to return used products at predetirmined value to enable next life for product. (Woldeyes et al., 2023)
		Collection and take-back of used products	Taking-back used products from distributors and end-users to close the material loop. (Woldeyes et al., 2023)
Extending	Strategies aim to prolong the	Lock-in	Encourages consumers to carry on using a specific product/service on a regular basis (Forum for Future, 2018)

use phase of products through durable design and maintenance to maximize the lifespan of resources (Geissdoerfer et al., 2020).	Modularity	Design devices of products into smaller parts that can then be independently created, used, and replaced (Forum for Future, 2018) (Woldeyes et al., 2023)
	Personalisation	Company creates data management opportunities that enable product personalisation (Forum for Future, 2018)
	Long-life products	Prolong the intrinsic life of the product through functional and aesthetic improvement, encouraging users to keep them in use (Colombo et al., 2021; Woldeyes et al., 2023)
	Repair and maintenance	Activities aimed to keep or restore a product in usable condition, extending its life span (Woldeyes et al., 2023)
	Lifetime products	High-end products claiming to last beyond a lifetime, and supported by design for durability and repair. (Pieroni et al., 2020)
	Products with life extension services	Products accompanied with additional high-quality services for life extension. (Pieroni et al., 2020)
	Hybrid model	Designing a product with a combination of durable products and short-lived consumables. (Pieroni et al., 2020; Woldeyes et al., 2023)
	Next life sales	Incentivizing customers to return used/unwanted items to the producer via a convenient system. Enable products to have a new life though refurbishment or remanufacturing. (Pieroni et al., 2020)
	Product transformation	Incentivizing customers to return used/unwanted items to the producer via a convenient system. Producer uses parts of the product or reprocessing it for application in another purpose. (Pieroni et al., 2020)
	Extending resource value	Incentivizing customers to return used/unwanted items via a convenient system. Manufacturers recycles the materials. (Pieroni et al., 2020)
	Repair and maintenance	Repairing and maintaining activities. (Woldeyes et al., 2023)
	Encourage sufficiency	Designing long-lasting products. Conscious actions to moderate sales activities. (Woldeyes et al., 2023)

		Upgrading	Replacing outdated modules or components with superior ones. (Woldeyes et al., 2023)
Intensifying	Strategies enhance the use intensity through sharing models and service systems that promote efficient use of products by multiple users (Geissdoerfer et al., 2020).	Product service system	Focuses on offering a solution rather than a product only, enhancing use intensity and promoting access over ownership (Forum for Future, 2018)
		Sharing economy	Encourage manufacturers to operate as service provders and to consider customers as users. (Colombo et al., 2021; Pieroni et al., 2020)
		Access model	Delivering customer service and related asset management without transferring the product physically. (Colombo et al., 2021; Pieroni et al., 2020; Woldeyes et al., 2023)
		Performance model or result model	Delivering functionallity/result rather than ownership. (Colombo et al., 2021; Pieroni et al., 2020; Woldeyes et al., 2023)
		Sufficiency economy	Moderating the consumption of end customers. (Colombo et al., 2021)
		Sharing or polling system/platform	Matching owners and users of overcapacities shared with some form or transactional arrangement for commercial purposes. (Pieroni et al., 2020; Woldeyes et al., 2023)
		Product-oriented PSS	Product-related training, advice, and consultancy services. (Woldeyes et al., 2023)
Dematerializing	Strategies involve replacing physical products with digital or service alternatives to maintain functionality without without physical resources (Geissdoerfer et al., 2020).	Digitalization	Virtualization of tangible assets. (Colombo et al., 2021)
		Dematerialised services	Replacing physical infrastructure/assets, services, or processes with digital/virtual services. (Pieroni et al., 2020; Woldeyes et al., 2023)
		Encourage sufficiency	Conscious actions to moderate sales activities. (Pieroni et al., 2020)
		Demand reduction services	Solutions that moderate the use of energy and resources by individuals and companies. (Pieroni et al., 2020)

C.2 Circular business model tools

Table C.2 Circular business model tools.

Title	*Description/Purpose*	*Source*
Designing the Business Models for Circular Economy – Towards the Conceptual Framework	Guidelines and tools for gathering data, analyzing performance, identifying areas for improvement, and implementing sustainability initiatives throughout the supply chain	Lewandowski, 2016)
Circular business models in the medical device industry: paths towards sustainable healthcare	Support businesses in transitioning towards circular supply chain models to minimize environmental impact and enhance long-term sustainability	(Guzzo et al., 2020)
Circular business model framework: mapping value creation architects along the product lifecycle	Structured approach for assessing the sustainability performance of supply chain activities, identifying opportunities for improvement, and implementing sustainable practices	(Nussholz, 2017)
The Circular Rebound Tool: A tool to move companies towards more sustainable circular business models	Support businesses in making informed decisions and implementing sustainable practices within their supply chain operations	(Das et al., 2023)
Assessing sustainability opportunities for circular business models	Structured framework for evaluating environmental, social, and economic aspects of supply chain activities	(Averina et al., 2022)
A transition framework for circular business models	Support businesses in understanding and minimizing the environmental footprint of their products throughout their life cycle	(Susur and Engwall, 2023)
Circular added value: business model design in the circular economy	Provides a comprehensive management instrument for designing, analyzing, and communicating circular business models, considering ecological, social, and economic dimensions of sustainable development.	(Morseletto, 2020)
A circular business model mapping tool for creating value from prolonged product lifetime and closed material loops	Systematic approach for integrating circular economy principles into business model design and innovation processes	(Nußholz, 2018)

Circular Business Models	Identify opportunities for circular business models by systematically designing processes that minimize waste and maximize resource cycling within the system	("IMSA-Circular-Business-Models-April-2015-Part-1.pdf," n.d.)
Critical appraisal of the circular economy standard BS 8001: 2017 and a dashboard of quantitative system indicators for its implementation in organizations	Support businesses in identifying opportunities for circular economy implementation and optimizing their sustainability performance.	(Pauliuk, 2018)
Sustainable Qualifying Criteria for Designing Circular Business Models	Support businesses in identifying strengths and weaknesses in their circularity efforts and guiding them towards more sustainable and circular business practices	(de Pádua Pieroni et al., 2018)

C.3 Circular business model innovation tools

Table C.3 Frameworks and tools for circular business model innovation tools.

Title	***Description/Purpose***	***Source***
Circular economy business model innovation process – Case study	Process tool to guide the overall BMI process (Bocken et al, 2019)	(Antikainen et al., 2017)
Assessing the environmental impact of new Circular business models	Rapid circularity assessment to assess the potential environmental impact of new business model ideas for clothing retailers (Bocken et al, 2019)	(Bocken et al., 2016)
A tool for manufacturers to find opportunity in the circular economy	Guidance through a database of value creating opportunity areas for the circular economy and assessment tool (Bocken et al, 2019)	("Circular Economy Toolkit," n.d.)
Emotional Durability Design Nine—A Tool for Product Longevity	Helps to implement an emotionally durable design in the new product development process (Bocken et al, 2019)	(Haines-Gadd et al., 2018)
Developing and implementing circular economy business models	Backcasting and Eco-design for the Circular economy (BECE) framework developed for the	(Heyes et al., 2018)

in service-oriented technology companies	service sector (ICT) aiming to be user-centric (Bocken et al, 2019)	
Circular economy in the building sector: Three cases and a collaboration tool	Collaboration tool for the building sector (Bocken et al, 2019)	(Leising et al., 2018)
Do circular economy business models capture intended environmental value propositions?	Rapid environmental assessment tool to help companies refine their environmental value proposition (Bocken et al, 2019)	(Manninen et al., 2018)
Integrating Backcasting and Eco-Design for the Circular economy: The BECE Framework	Comprehensive CE tool with design elements (Bocken et al, 2019)	(Mendoza et al., 2017)
A circular business model mapping tool for creating value from prolonged product lifetime and closed material loops	Collaborative CBM mapping tool (Bocken et al, 2019)	(Nußholz, 2018)
Measuring the Readiness of SMEs for Eco-Innovation and Industrial Symbiosis: Development of a Screening Tool	Screening tool to support companies explore the potential for eco-innovation with a focus on IS and industrial symbiosis. (Bocken et al, 2019)	(Pigosso et al., 2018)
Consumer Intervention Mapping: A Tool for Designing Future Product Strategies within Circular Product Service Systems	Tool for creating future circular product strategies (Bocken et al, 2019)	(Sinclair et al., 2018)
'All they do is win': Lessons learned from the use of a serious game for Circular economy education	Experiential learning game for educating about material criticality and CE (Bocken et al, 2019)	(Whalen et al., 2018)
Risk and Race: creation of a finance-focused circular economy serious game	Finance-oriented CBM game (Bocken et al, 2019)	(Whalen, 2017)
Sustainability in the Circular Economy: Insights and Dynamics of Designing Circular Business Models	Systematic method for analyzing various aspects of business operations to identify opportunities for improvement and innovation in alignment with circular economy principles.	(Awan and Sroufe, 2022)
The Circular Sprint: Circular business model innovation though design thinking	Tools and guidelines for businesses to integrate CE principles into their BM	(Santa-Maria et al., 2022)

Experimenting with a circular business model: Lessons from eight cases	Structured approach for businesses to assess their current practices and implement sustainable solutions to facilitate the transition towards a circular economy	(“Circular ecosystem innovation portfolio management - ScienceDirect,” n.d.)
Circular ecosystem innovation portfolio management	Guides businesses in making decisions that balance environmental sustainability with economic viability in their supply chain operations	(Gomes et al., 2023)
Product design and business model strategies for a circular economy	Structured approach for assessing the sustainability of various aspects of the fashion supply chain.	(Bocken et al., 2016)
A Framework for Sustainable Circular Business Model Innovation	Structured approach for businesses to develop new models that align with principles of sustainability and circular economy	(Antikainen and Valkokari, 2016)
Circular Business Model Innovation: A process framework and a tool for business model innovation in a circular economy	Tool for businesses to visualize and analyze their entire business cycle, rather than just individual business models	(Mentink, n.d.)