Iben Bolund Nielsen

BUSINESS PERSPECTIVES FOR ENABLING CIRCULAR ECONOMY

ACTA UNIVERSITATIS LAPPEENRANTAENSIS 1245

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Abstract

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There are many challenges facing the world's population at the moment. One of these is the environmental degradation linked to the way parts of humanity live their lives. To mitigate, or even reverse, this negative trend, we need to address the way we consume and produce products. Circular economy (CE) is an economic system in which materials are circulated and waste is eliminated to reduce the negative environmental impact the current economic system causes. The current economic system is linear and focused on economic prosperity, without considering the consumption of resources.

Transitioning from a linear to a CE is a contemporary phenomenon impacting many businesses. However, the transition is in the emerging stages and CE has yet to come of scale. To support and enhance the adoption of CE, a better understanding of CE enablers is necessary and research gaps in this area were identified. Thus, the purpose of this dissertation is to understand how CE enablers facilitate the implementation of CE practices.

The research takes a qualitative case study research approach, with two inductive and two abductive studies. Data is primarily based in interviews with representatives from businesses based in Finland. The methods employed include thematic analyses, the descriptive framework method, and content analysis methods.

The findings suggest that CE enablers facilitate the implementation of CE practices by changing the status quo, thereby prompting action from individual businesses, and that digital technologies and technological advancements accelerate the implementation of CE practices. These findings contribute to the CE enabler literature by introducing original insights from businesses by tying macro with micro level CE enablers.

Keywords: Circular economy enablers, circular economy

Acknowledgements

After working with corporate sustainability for almost a decade, my professional and personal curiosity was piqued when I repeatedly discussed circular economy (CE) with local business leaders who did not think CE would ever be widely applied. I initially understood their hesitation, because CE not only requires changes internally within a company, but is also simultaneously dependent upon external stakeholders and systems changing their strategies, business models, and interests, in addition to regulatory changes. Nevertheless, CE seemed on the other hand to offer a roadmap for a way to do things better, and more. I understand that CE is complex, and for individuals, businesses or even regional authorities to be able to organize and implement any form of CE comes with challenges. Challenges, however, are something to be overcome and to be solved, and I have a strong interest in solving puzzles – or, in this case, circular challenges. My curiosity subsequently turned into a craving for knowledge and in-depth learning, and when a junior researcher position at Lappeenranta-Lahti University of Technology (LUT) opened up, I immediately applied. I had a strong feeling that CE may be just what we need to make a proper change in the way the world is progressing, and for me personally to be part of driving that change in the corporate world.

After nearly two intense years of full time PhD studies at the LUT satellite campus in Mikkeli, I made the difficult decision to continue my studies in my spare time while returning to a corporate sustainability job. It is difficult to say whether this was the right or wrong decision, but it is safe to say it added an additional stress factor to my doctoral journey. During my interview for the junior researcher position, I was asked how I dealt with stress, to which I answered “I go for a good long run”. Now, many miles and even marathons later, my PhD journey has come to an end, even though I am quite assured that the learning will continue. I am proud of this substantial achievement, both professionally and personally, and grateful for being able to live in a time and place that has allowed me to pursue this dream.

This knowledge-intensive journey would not have been possible without the aid and support of my two supervisors Professor Dr. Henri Hakala and Dr. Sanne Bor – both of whom have had patience with me, worked to accommodate my work schedule, and provided innumerable advice, feedback and insights based on their long-time dedication to and experience in this field. We have had many good discussions and challenged each other, which has helped me grow not only as a researcher and sustainability professional but as a person as well. Similarly, I would like to extend my thanks and appreciation to my co-authors, research group, colleagues and everyone else at the LUT satellite campus in Mikkeli.

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I would also like to extend my gratitude to my opponent, the reviewers and the chair of the defense committee for providing invaluable inputs to the dissertation.

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Iben Bolund Nielsen
August 2025
Aarhus, Denmark

To past, present and future dreams

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Publications

List of publications

This dissertation is based on the following papers. The rights have been granted by the publishers concerned to include the papers herein.

I. O'Shea, G., Luoto, S., Hakala, H., Bor, S. and Nielsen, I.B. (2021). The circular water economy and the 'seven C's'. Research Handbook of Innovation for a Circular Economy. Edward Edgar Publishing. DOI: 10.4337/9781800373099.00020

II. Nielsen, I.B. and Hakala, H. (2022). External enablers for the circular economy: A case study of the food packaging industry. Journal of Cleaner Production. DOI: 10.1016/j.jcleprp.2023.137915

III. Nielsen, I.B. (2025). The Changing Activities of Circular Economy Frontrunners: What Do Food Packaging Manufacturers Do to Accommodate the Circular Economy? Sustainability Transition in Food Packaging: Concepts, Methods and Practice. Springer. DOI: 10.1007/978-3-031-87492-5_7

IV. Ghoreishi, M., Nielsen, I.B., and Pynnönen, M. (2025). Adaptation of Artificial Intelligence by start-ups for a Data-driven Circular Economy: Evidence from Multiple case-study in Finland. Digital Transformation and Business Sustainability From Theory to Practice. Routledge. DOI: 10.4324/9781003433743-4

Author's contribution

Publication I: I was part of planning the interviews and supported and reviewed the interview guide. Furthermore, I wrote parts of the background and methodology sections, and assisted in revising the final version of the paper.

Publication II: I was the principal investigator and corresponding author. I developed the research plan with the co-author. I wrote the majority of the manuscript, which was then reviewed and discussed with the co-author.

Publication III: I was the sole investigator and author.

Publication IV: Has already been included in the doctoral dissertation by Ms. Malahat Ghoreishi. I was one of the two main authors. Together with the other main author, I co-developed the semi-structured interview guide, and the interviews were conducted with both main authors present. I transcribed all the interviews and wrote background text on CE as well as the methodology section.

Nomenclature

Abbreviations

AI	Artificial intelligence
B2B	Business to business
CBM	Circular business model
CE	Circular economy
CO2	Carbon emissions
DT	Digital technology
EE	External enabler
EU	European Union
IoT	Internet of Things
RQ	Research question
SD	Sustainble development
SME	Small and medium sized enterprise

Declarations

Turnitin

The originality of this dissertation has been reviewed with the Turnitin similarity checking service.

Commercial software

This dissertation was prepared with the help of the following commercial software:

NVivo 12 - a qualitative data analysis software that used for data coding, classification and analysis. NVivo licensed software is provided by LUT University for the researchers. I utilized NVivo 12 for the qualitative data coding and analysis in Publications I, II and IV.

AI use

Iben Nielsen, the author of the dissertation, did not use any AI tools during the preparation of this doctoral dissertation.

1 Introduction

1.1 Research environment and background

Environmental degradation, resource scarcity, pollution, and climate change are buzzwords many of us encounter on a regular basis. These highly negative buzzwords describe the current state of the earth with little improvement in sight. 2024 even witnessed the highest concentration of CO_2 in the atmosphere contributing to continued climate change (International Energy Agency, 2025). These negative developments are, either directly or indirectly, linked to the way humans live their lives (Calvin et al., 2023).

Not only is the degrading state of the world impacting our everyday lives, but businesses now, more so than ever, are also impacted by the changing climate and related consequences. Many businesses depend upon the use of natural resources, having built their businesses on the availability of resources of a certain quality and volume. On the flip side, a side effect of production processes can be the pollution of air, soil and water. Furthermore, the production of goods can also result in littering and other harmful practices like microplastics ending up in the environment, human food supplies, and human beings (Tynkkynen et al., 2025). Since the industrial revolution, we have seen an immense growth in the human population and the closely associated production and consumption systems of the world, contributing to the continued problematic situation due to rising demands and consequent production volumes (Calvin et al., 2023).

Over the last century or so, there has been a growing awareness that our means of producing and consuming goods and services exert a profound impact, both for humanity and the environment (Commission, 1987). These consequences will impact future generations who will encounter depleted resources as well as permanent and serious changes incurred to the environment and climate. To reverse, reduce, or avoid the continuation of this negative environmental trend, humanity must start living within the planetary boundaries of the Earth. However, the prevalent economic model still follows a linear economy pattern that does not take resource scarcity, climate change and environmental health into consideration, continuing to make, use, and discard products – an economic model that has dominated since the industrial revolution (Neves & Marques, 2022). With the growing recognition that there is a price to be paid when air, soil, and water are no longer clean and healthy for current and future generations, alternative economic systems are necessary. Circular Economy (CE) is one such alternative: an economic system that purposefully retains resources and eliminates waste while restoring and regenerating natural resources (Bocken & Geradts, 2022).

An ideal CE is an economic system that mimics nature in which all materials continuously circulate as nutrients, thus eliminating waste and decoupling economic prosperity from resource depletion (N. Bocken et al., 2025). Therefore, a CE can be described as a complex system of organizing production and consumption systems. This system is intentionally designed to minimize greenhouse gas emissions, resource use, waste and

pollution, while maximizing the value of material resources (Konietzko et al., 2020). Above all, a CE emphasizes the need to maintain and prolong the use of any product, thus championing longevity, upgradability and repairability as an integral part of the design phase (Schulz et al., 2019).

CE is a research topic gradually gaining ground and popularity in academia with definitions being proposed and revised regularly (Kirchherr, Yang, et al., 2023), circular business models (CBMs) explored (Geissdoerfer et al., 2020), implementation strategies investigated (De Pascale et al., 2023), and the barriers as well as enablers identified and discussed (Kirchherr, Bauwens, et al., 2023; Kirchherr et al., 2018). CE is not only gaining ground in academia, however: countries and regions have also initiated measures to introduce, implement and accelerate CE. The European Green Deal and Circular Economy Action Plan are examples of measures introduced that set the direction within the EU, with implications for both businesses and authorities (European Commission, 2015).

The purpose of this dissertation is to understand how the implementation of CE practices in businesses can be enabled and thereby learn more about the path to CE and how it may be supported. Understanding which and how enablers aid businesses in the transition to a CE is crucial to improve and accelerate the adoption rate of CE in practice.

1.2 Motivation

For CE to be meaningful, changes across the micro-, meso- and macro level of society are necessary (Merli et al., 2018). These changes affect businesses, particularly those operating in countries and regions with national and regional authorities legislating in support of CE, including the EU (Domenech & Bahn-Walkowiak, 2019). For this reason, many companies must now contemplate, monitor, and mitigate their environmental impact in order to be compliant with legislation (McDowall et al., 2017). The extent of the changing practices businesses are implementing vary, as do the practices themselves. As businesses commence on the path to CE, they are encountering both barriers and enablers, added to the need to revise their business practices (Tura et al., 2019). Enablers for CE support the transition for businesses and therefore may hold great potential if understood better.

Extant literature on CE enablers is fragmented and diffuse (Sinha, 2022); it is, however, growing, and several enablers of CE have been identified in recent years. At the meso-level, the following CE enablers were identified and ranked as the top five most important and promising 1) regulatory pressure, 2) economic incentives, 3) consumer demand, 4) corporate responsibility, and 5) technological advancements (Min et al., 2024). With some overlap at the micro-level, the following seven CE enablers were identified through a systematic literature review: 1) business model innovation, 2) knowledge management, 3) top management, 4) organizational resilience thinking, 5) employee engagement, 6) technological advancements, and 7) organizational size (Sinha, 2022). Addtionally, the following six enablers of managerial practices for CBM design at the micro level were

listed as 1) supply chain interactions, 2) technological innovation, 3) sustainable value creation, 4) servitization and platformization, 5) values and culture, and 6) governmental policies (Vecchio et al., 2024). CE enablers have also been studied from an ecosystem perspective where the following seven categories of enablers were identified 1) ecosystem actors' inclination and collaboration, 2) standardization, 3) regulation and external support, 4) competitive costs and benefits, 5) capabilities and resources, 6) innovative applications, and 7) supply chain structure, again, with some overlap with the other studies (Toorajipour et al., 2024).

Other studies have approached the exploration of CE enablers differently, by focusing on investigating single enablers in-depth, including policy instruments, standardization (Anastasiades et al., 2021), and collaboration (J. L. Mishra et al., 2019), as well as a multitude of digital technologies (DT) (Ingemarsdotter et al., 2020; Voulgaridis et al., 2024; Wilts et al., 2021). Prior literature has also studied CE enablers in various industries (Nyffenegger et al., 2024; Suman & Rajak, 2025) and countries (Ranta et al., 2018; Sharma et al., 2024), along supply chains (Yadav & Singh, 2024), and in startups (Van Opstal & Borms, 2023) and SMEs (Rizos et al., 2016), among other contexts.

Finally, in an editorial, Kirchherr et al. (2023) bluntly states that digitization may be one of the most under-estimated enablers of circular disruption (Kirchherr, Bauwens, et al., 2023). This argument may hold some truth, though some studies have identified several DTs as enablers for CE (Atif, 2023; Voulgaridis et al., 2024) and, as listed above, technological advancements are repeatedly listed as a CE enabler and thus encompass a number of technologies.

1.3 Research gaps

As presented in the introduction, CE is a complex and emerging research topic in academia: it is therefore only natural that numerous research gaps exist. The following section will present the research gaps related to CE enablers identified as the basis for this dissertation.

A CE enabler can be defined as a factor facilitating and supporting the adoption of CE (Rittershaus et al., 2025) or key success factors, drivers or indicators (Yadav & Singh, 2024). In this dissertation, it is understood as a concept, context, object, action or event that facilitates CE to be pursued, accelerated, adopted, or implemented. Not only uncovering the factors, drivers or indicators of CE but also understanding how they are leveraged and internalized into actionable practices will contribute to theoretical and practical knowledge concerning the path to CE.

To understand the path to CE and how enablers can have the desired effect and impact, it is crucial to extend our knowledge and learn which role enablers play in the implementation of CE practices. One way to do this is to investigate how CE enablers are leveraged to learn how CE is adopted, adjusted, and implemented by practitioners in

different contexts. An initial step towards successful implementation of CE is to identify enablers and how they are leveraged (Toorajipour et al., 2024).

Several studies have identified CE enablers but have yet to bring forward research including a variety of company sizes and industries to present a fuller picture of enablers advancing CE. Additionally, only a few studies try and bridge the link between the identified enablers and which practices businesses choose to focus on to become more circular. In other words, there is a knowledge gap regarding the relationship between CE enablers and changing business practices. Empirical studies could help bridge this gap by exploring what businesses are doing in the current business environment. Early empirical studies focused on CE in China, UK, Denmark, Germany and the Netherlands (Ghisellini et al., 2016). More recent studies appear to focus on the implementation of CE business models (Ingemarsdotter et al., 2020; Salvador et al., 2020; Straub et al., 2023) and which implementation strategies in the EU are most utilized (De Pascale et al., 2023). Therefore, it could be argued that the exploration of how CE enablers facilitate the implementation of CE has not been explored thoroughly but is nevertheless a crucial area to explore as a prerequisite for a transition to CE to occur.

One CE enabler specifically mentioned above is the technological enabler, and arguably, the next significant development affecting how businesses operate is Artificial Intelligence (AI): yet again, further studies are needed to understand where and how they are embedded (Nielsen & Hakala, 2023). The literature is limited regarding whether and how startups in particular utilize AI to accelerate CE. Literature on both CE and AI is rapidly increasing, but how they interact and, in this case, how they are used to accelerate the adoption of CBMs is lacking. Thus, another research gap was identified at the intersection between AI and CE that could be addressed through empirical investigation.

In light of the above identified research gaps, the main research gap this dissertation will explore is how CE enablers aid the implementation of CE practices. This will be done by focusing on empirical studies among CE practitioners in three individual contexts where CE is at the core of the businesses concerned. The three contexts are: 1) a CE-focused entrepreneurial ecosystem, 2) the food packaging industry, and 3) CBM based startups. Below is a short justification of each context as an empirical research setting.

On the one hand entrepreneurs and entrepreneurial endeavors focused on CE potentially feed the pipeline of novel and innovative products and solutions. Understanding how this particular business segment feel encouraged and supported in their new venture creation pursuit and what they need to succeed may unlock findings that could accelerate the transition to CE. On the other hand, large scale innovation and development is critical for success for the multibillion dollar food packaging industry. The industry continuously undergoes change due to increasing population growth, marketing and communication experiements and environmental concerns. Additionally, the food packaging industry is subject to strict regulations compared to other industries, due to the high volume of single-use packaging (European Commission, 2015). Lastly, CBM based startups can play a key role in the systemic change towards CE since they approach and engage different

strategies and actors compared to more mature startups and incumbents (Van Opstal & Borms, 2023). With DTs possibly being the most under-estimated enabler of CE disruption, exploring if and how CE startups utilize DTs extends our knowledge and understanding of this topic. With AI revolutionizing the ways of working, exploring the adoption rate of this technology and how it is used adds a critical dimension to the exploration of CE enablers. Therefore, investigating industries where innovation and development in startups and incumbents are present is needed to address the research gaps identified above.

1.4 Aim and research questions

The aim of this dissertation and the four studies is to expand, improve and extend knowledge on the implementation of CE through the investigation of CE enablers. For CE practices to be implemented and have a wider societal impact, CE enablers play an important role. By understanding the relationship between CE enablers and the implementation of CE practices, insights may be used to accelerate the CE adoption rate among practitioners as well as support authorities to activate the appropriate political tools for CE. CE practices differ, yet many contextual aspects are also similar for businesses: studying, thus, how businesses commence on the path to CE adds valuable contributions to future theorizing and conceptual development for CE research.

This dissertation builds on four qualitative peer-reviewed scientific research publications that combinedly seek to answer the following main research question (RQ):

How do circular economy enablers facilitate the implementation of circular economy practices?

The intent is to provide detailed insights and contribute to the growing knowledge base with carefully designed empirical case studies investigating aspects of this main RQ. The dissertation does not intend to find a 'one-size-fits-all' answer to this question, as such an answer may not be feasible; however, it is the intent to bring forward aspects that add insights to this RQ. Additionally, contributing to the knowledge base with detailed descriptions of contexts and findings should offer some generalizable findings if applied cautiously. The main RQ is therefore supported by four sub questions (SQ) to break down and identify aspects addressable as part of the research. The following SQs are included in this dissertation and add individual perspectives to the RQ:

SQ I: *What enablers need to exist within the local sustainability-focused entrepreneurial ecosystem in order to engage and support innovative CE-focused entrepreneurs?*

This first SQ is studied through Publication I, and seeks to identify CE enablers and develop a framework based on the CE enablers identified. The framework is developed for ecosystem enablers that support and encourage local sustainability-focused entrepreneurs that are engaged in a circular water economy. In particular, the framework has been developed to better understand the enablers that engage and support CE-focused

entrepreneurs. The details of this publication are described later in the dissertation, including the methodology and methods presented in sections 3.1 and 3.3 as well as the results in section 4.1.

SQ II: *How is the food packaging industry leveraging external enablers during the transition to a circular economy?*

This second SQ is studied through Publication II and aims to investigate how external enablers (EE) are leveraged when businesses are transitioning from a linear economy to a CE. It does so by studying self-proclaimed CE frontrunners in the food packaging industry. Additionally, this SQ investigates multiple EEs acting as one circular EE and how this affects these businesses, which is a novel approach to studying EEs. Further details are presented later in the dissertation, including the methodology and methods used in sections 3.1 and 3.3, in addition to the results in section 4.2.

SQ III: *What activities are changing in CE frontrunner firms implementing CE-related innovations in the food packaging industry?*

This third SQ is studied through Publication III and investigates the activities undergoing changes on the path to CE. The publication shares the same dataset as Publication II. The publication brings examples from businesses and elevates the findings to five 2nd order themes and two aggregate dimensions. Additionally, the publication shows how the five themes interact with each other. The methodology and method used for this study are presented in sections 3.1 and 3.3, and the results in section 4.3.

SQ IV: *What is the current implementation of AI in data-driven CBMs by startups?*

The final SQ is studied through Publication IV and studies how startups utilize AI for data-driven CBMs, thereby adding a technology layer to the path to CE. The methodology and method used for this study are presented in sections 3.1 and 3.3, and the results in section 4.4.

Table 1 below is an overview of the RQ and SQs addressed in this dissertation, along with the objectives. The dissertation intends primarily to provide empirical evidence of CE enablers based on data collected from businesses based in Finland. The dissertation bridges a gap between theoretical CE research and the implementation of CE in industry. The aim of the study is to provide new insights into how CE enablers are leveraged by businesses pursuing CE.

Table 1 Research topics, objectives and questions

Main RQ:				
Subquestions	What enablers need to exist	How is the food	What activities are changing in	What is the current

	within the local sustainability-focused entrepreneurial ecosystem to engage and support innovative CE-focused entrepreneurs?	packaging industry leveraging external enablers during the transition to a circular economy?	CE frontrunner firms implementing CE-related innovations in the food packaging industry?	implementation of AI in data-driven CBMs by startups?
Objectives	Identify enablers for local sustainability focused entrepreneurial ecosystems to support CE-focused entrepreneurs	Understand how external enablers are used in the transition to a CE in the food packaging industry	Identify the activities that are changing within businesses claiming to be CE frontrunners in the food packaging industry	Understand how startups adapt AI to offer a business model relevant for a CE
Publication	I	II	III	IV

A qualitative methodology is employed in this dissertation and in the four published studies. Two of the studies are of an inductive nature and two of an abductive nature. Each publication is a case study and utilizes various work methods, though all use semi-structured interviews as the prevalent data collection method. Publications I and IV use a thematic analysis method, while Publication II uses a descriptive framework analysis and Publication III a content analysis method. The methodology, methods and data handling will be further explained in the methods section, 3.3.

1.5 Scope and limits

CE is a complex and much-encompassing concept, it has therefore been necessary to draw limits for this study. The first delimitation of scope is the focus on CE enablers and the path to CE. Due to the pressure for businesses to adopt and accelerate CE practices, the scope of this study is to learn about and explore CE enablers and how they aid the implementation of CE practices. However, in line with the qualitative studies, it is not in scope to present a map of all enablers but rather a full picture of certain aspects showcasing how CE practices may be implemented as based on CE enablers. Table 1

above illustrates the positioning of the research presenting the RQs and objectives studied.

Further limitations to the scope of study include the geography of the collected data. All data were collected from Finland-based entrepreneurs, startups and incumbents, though the latter have international operations and markets. Since the study is focused on CE enablers and Finland has had a focus on CE on a national level, data availability and accessibility seemed to outweigh the potential benefits of including data from more countries. Closely related, it is another limitation of the data that the entrepreneurs, startups and incumbents had to know and actively work with CE to be considered for this study. This design of the scope of study is to ensure in-depth and thick data for the case studies.

The dissertation builds on a theoretical background of CE enablers which draws relations to sustainable entrepreneurship studies and external enablement and how these engage with CE. The dissertation has been designed to contribute empirical credence to the rapidly increasing literature on CE in general and CE enablement in particular.

1.6 Contributions

This dissertation identifies 14 CE enablers and explores how they facilitate the implementation of CE practices. The 14 enablers are 1) competencies availability, 2) customer availability, 3) connector availability, 4) collaboration, 5) coordination, 6) culture, 7) a center, 8) political, 9) regulatory, 10) sociocultural, 11) technological, 12) AI-based analytics, 13) mobile apps, and 14) algorithms.

The dissertation shares two perspectives on how these 14 CE enablers facilitate the implementation of CE practices: 1) CE enablers change the status quo, thereby prompting action from individual business, and 2) DTs and technological advancements accelerate the implementation of CE practices. The CE enablers are found to support and engage entrepreneurs, shape, enhance and trigger venture creation, change business and material practices, and assist with customizable data collection, analysis and interpretation.

The dissertation contributes to CE research by providing original insights and advances knowledge from businesses implementing CE practices. It contributes original insights to the literature on CE enablers by explicitly tying macro level CE enablers with micro CE enablers. The novel contributions to the literature on CE enablers are discussed in section 5.1. The findings are also interesting from a practitioner's perspective, as they provide tools and insights relevant for managers, policy makers and startups as well as for entrepreneurial ecosystems. Practitioners should pay attention to the findings highlighting how CE enablers at the macro level unlock micro level CE enablers.

1.7 Overview of the dissertation

This section explains the structure of the dissertation. The current chapter briefly introduces the background, context, research gaps and focus of the study. The dissertation then goes into more detail in the following chapters and is organized as follows: This chapter is followed by a state-of-the-art section where existing literature focusing on CE enablers will be introduced, assessed and discussed. The methods section commences with an introduction to the research paradigm of the study and continues to present and explain the relevant methods applied throughout the publications. Thereafter, the results section presents a summary of each of the four scientific publications included in the dissertation, after which the results will be presented. Finally, a discussion follows, in which the contributions to literature and managerial practice will also be presented. Lastly, the concluding section summarizing the highlights of the study and the publications are provided as attachments at the end.

2 Circular economy and its enablers

This chapter introduces the core concepts related to CE enablers relevant for the dissertation to provide background on the theoretical underpinnings. The chapter is divided into three different sections: Section 2.1 presents the CE concept and context to explain and emphasize the complexities of CE that are relevant for the dissertation and section 2.2 explains the resource flow management in CE, while section 2.3 ends the chapter with an overview of CE enablers.

2.1 The circular economy concept

Academia has seen an exponential rise in research publications studying CE with publications having increased from just 12 in 2008 to 2355 publications in 2020 (Alcalde-Calonge et al., 2022), which is also evident from the large number of review articles published on this topic (Dzhengiz et al., 2023). Due to this contemporary and high interest topic, it might be the most discussed concept in academia in recent years (Kirchherr, Bauwens, et al., 2023). Despite having only substantially risen as a topic of interest to the research community around 2008, the high volume of research publications has contributed to CE reaching the threshold state of maturity relatively quickly (Kirchherr, Urbinati, et al., 2023).

CE research has seen many definitions proposed and avenues of study (Kirchherr et al., 2017). The concept itself has experienced both consolidation and differentiation in recent years (Kirchherr, Yang, et al., 2023). Most researchers agree that CE purposefully retains resources and eliminates waste while restoring and regenerating natural resources (Velenturf & Purnell, 2021). This is in stark contrast to a linear economy, where products and materials become waste at the end of their useful lives. However, the linear economy is the globally predominant economic model (Stahel, 2016), even if this economic model has dire consequences for environmental and human health and is therefore unsustainable in the long run (Crainer, 2013). To ensure that the Earth and its environmental health and abundance are available for future generations to enjoy, sustainability must be included in human decision-making (IPCC et al., 2019).

Sustainable development (SD) as an overarching theme is generally accepted as a necessity for the wellbeing of the ever-increasing world population, and as the World Commission report *Our Common Future* eloquently stated in 1987: "*Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Commission, 1987). The report specifically and powerfully emphasizes that humanity has a choice, the ability, to develop sustainably. To reduce or even reverse the negative consequences the linear economy is leaving in its wake, an alternative economic model is needed. CE offers a seemingly positive compromise by bringing environmental aspects into mainstream economics (Ingebrigtsen & Jakobsen, 2006). It is therefore often posited as an essential part of SD and instrumental for sustainability, while maintaining global

economic growth decoupled from resource consumption (George et al., 2015) as a desirable and plausible outcome.

It is a widely used approach among scholars to research, analyze and interpret CE within a SD context (Suárez-Eiroa et al., 2019). Although a large part of it does so, not all of the literature views CE as a condition for SD. The other stream of CE literature debates whether and how CE and sustainability are conceptually related. Some researchers meticulously argue that CE and SD are only weakly related and that a link is even questionable, as SD focuses on people and economic activity as the means to this end while CE is focused on technological advancements leading to traditional economic growth (Velenturf & Purnell, 2021). Others argue that CE only fosters certain aspects of sustainability while ignoring or not addressing others (Geissdoerfer et al., 2017).

This dissertation follows the majority literature stream in which CE is understood as closely linked with SD, focusing on a subset of sustainability aspects as guided by the governing principles of CE (Velenturf & Purnell, 2021). Figure 1 visualizes how CE is linked to SD, though the two do not overlap completely as this stream of literature does not consider the social aspects of sustainability as part of CE.

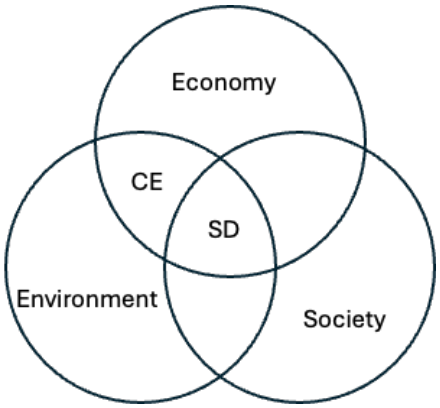

Figure 1 Visual presentation of the alignment between CE and SD, developed as based on work by Murray et al., 2017

Not only can it be argued that CE and SD are closely linked, but it has also been suggested that CE, with its narrow framework compared to sustainability – providing direction for industry implementation – may be a new sustainability paradigm (Geissdoerfer et al., 2017). This potentially new sustainability paradigm focuses on resource and material efficiency and circulation, maximizing the value of products, minimizing waste, emissions and pollution, while maintaining products and materials at their highest value for as long as possible (N. Bocken et al., 2025). The former sustainability paradigm was more vague, diffused by an excessive number of goals and a lack of clearly defined

responsibilities and roles (Geissdoerfer et al., 2017). The aims of CE can be summed up in the following way:

> "*The circular economy is an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development through its implementation at the micro (enterprise and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels. Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes."* (Prieto-Sandoval et al., 2018).

The emergence of CE has also been met by critique beyond whether it is linked to SD or not. One critique of CE is the lack of a common definition (Corvellec et al., 2022), which has been detailed in plenty of research but succinctly described in a study discussing, comparing and contrasting 114 identified definitions of CE (Kirchherr et al., 2017). It is only natural that an emerging research topic and concept undergoes a phase in its infancy in which various definitions are proposed and investigated (Korhonen et al., 2018). Therefore, a lack of a common definition could encourage further research, including further critiquing to challenge, evaluate and further grow the knowledge and contributions to CE. This dissertation defines CE in accordance with its most employed definition as "*an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.*" (Kirchherr et al., 2017).

Another critique of CE is the utopian portrayal of a CE that eliminates waste and emissions while creating a fully closed cyclical system, as this is simply not feasible (Corvellec et al., 2022) and may cause paralysis rather than spurring action (N. Bocken et al., 2025). CE literature rarely discusses the 'more circular' or 'less linear' path to CE, despite the acknowledgement that CE demonstrates high complexity in organizing a fully circular system. CE practices are stepping stones on the path to CE and may act as indicators on which and how enablers facilitate this implementation.

Further critique of CE has been grouped into three types of underlying assumptions of CE: 1) in-house assumptions, in which schools of thought proceed without assessing and discussing the assumptions on which the research is grounded, 2) root metaphor assumptions where metaphorical comparisons are made without explicit reason or further discussion of the comparisons made, and 3) ideology assumptions in which political beliefs or morals are linked with the CE concept, though not made explicit or justified (Dzhengiz et al., 2023). These critiques of CE will not be further explored in this dissertation, since it is not a study of the CE concept or its flaws. It suffices to say that

there are critiques of CE, yet the study exploring the CE enablers facilitating CE practices can continue despite CE having conceptual flaws.

Despite the high number of CE publications in academia, the Circularity Gap report detailing the global circulation of materials indicates that the circulation of material in practice decreased from 9.1% in 2018 to 7.2% in 2023 (Circle Economy, 2024). This decline occured despite the introduction of new and more stringent legislative measures in Europe and China developed to support, accelerate and initiate more CE practices being adopted (McDowall et al., 2017). Furthermore, empirical evidence from studies shows that CE implementation in manufacturing industries occurs (Bjørnbet et al., 2021) including in India (Dohale et al., 2023; Sharma et al., 2024; Suman & Rajak, 2025) and China, which are both home to large scale manufacturing industries (Lieder & Rashid, 2016). Therefore, understanding the path to CE is crucial, since the academic hype does not appear to extend to practice. This disalignment is interesting in a time where CE seems to be a critical part of the solutions to global environmental challenges. Nevertheless, it appears that CE adoption rates ar not increasing at the same speed as the products and materials coming to the end of their useful lives.

As CE is a shift from a linear to a circular economic model, the implementation of CE is dependent upon the economic feasibility of any given CE initiative (De Pascale et al., 2023). Perhaps for this reason, little CE disruption is evident in business so far, even if some industries may be ready for it (Kirchherr, Bauwens, et al., 2023). There have been attempts to develop frameworks to measure the maturity of circularity of products (Aguiar & Jugend, 2022) and of CBMs (Sehnem et al., 2019) that have yet to be adopted broadly. Therefore, not surprisingly, one study found that CE theory and practice must be better linked to gain full advantage of the benefits, and that it is crucial that CE is not only implemented within an organization but also, more holistically, externally in collaboration with stakeholders (Barreiro-Gen & Lozano, 2020). CE is, at least in theory, a solution to several global contemporary challenges while focusing on the economic aspects of doing business, yet the global circulation of materials is decreasing from year to year. It is thus of the essence to uncover how, intentionally or unintentionally, enablers facilitate the implementation of CE to bridge the gap between theoretical ripeness and practical decline.

2.2 Resource flow management for CE

Based on the above-mentioned definition and aim of CE, the management of resource flows is at the core of CE. Early on in CE research, a specific terminology around the management of CE resource flows was developed to describe the difference between resource flows in a linear economy to those in a CE. Three categories have been described: the slowing, closing and narrowing of resource loops (N. Bocken et al., 2016). The slowing of resource flows refers to the extended use and reuse of products over time, which is facilitated through design that enables, supports, and ensures a long use stage and opportunities for maintenance to further extend the life of a product (Geissdoerfer et

al., 2018). Slowing the resource loop can be done by designing: 1) products to have long lifetimes and durability, and 2) for extension of product lifetimes through maintenance, repairs and upgrading (N. Bocken et al., 2016). These design strategies for slowing resource flows have since been elaborated on, by emphasizing multiple product functions such as circular behavior, reliability, reuse, remanufacturing, product-service-systems, and repurposing (Aguiar & Jugend, 2022). The essential part of slowing a resource flow is to ensure that a resource in a CE stays in use for as long as possible before leaving the market and circulating back again as a raw material, thus becoming part of the closing of resource loops.

The closing of resource loops can be described in terms of reuse and recycling and may involve reverse logistics where products at the end of their lives are taken back directly or collected in certain locations (Geisendorf & Pietrulla, 2018). Closing the resource loop can be done by designing 1) for a technical cycle in which products are designed to continuously be recycled into new materials, 2) for a biological cycle, which is relevant for products aimed at consumption rather than services and therefore biodegradable, and 3) for disassembly and reassembly, so that products can (easily) be separated – this being relevant for both recycling and upgradability or exchange of parts (N. Bocken et al., 2016). These have later been further broken down into design strategies emphasizing recycled materials, mono-materials, materials adequate for primary recycling, and recyclability (Aguiar & Jugend, 2022), in addition to the three aforementioned product design strategies. If successful, closing the resource loops directly reduces the need for primary resources, as they keep being circulated as a secondary resource. There are limits to the number of times some materials can be recycled, but they still reduce the need for primary resources when continuously looped.

The narrowing of resource flows refers to the reduction of resources used per unit produced and is therefore about resource efficiency (N. Bocken et al., 2016). Resource efficiency initiatives can be translated into several CE design approaches: 1) low-impact inputs, 2) light weighting, 3) energy efficiency, 4) standardization, 5) production improvements, and 6) modularity (Aguiar & Jugend, 2022). Resource efficiency is also known from the linear economy where the goal was cost reduction due to lower material costs when less material was used. For CE the goal is different, resource efficiency means that the optimal amount of material is used so that a product can still fullfill the slowing and closing of resource loops in conjunction with process effiency. The figure below is a visual presentation of the slowing, closing and narrowing of resource flows.

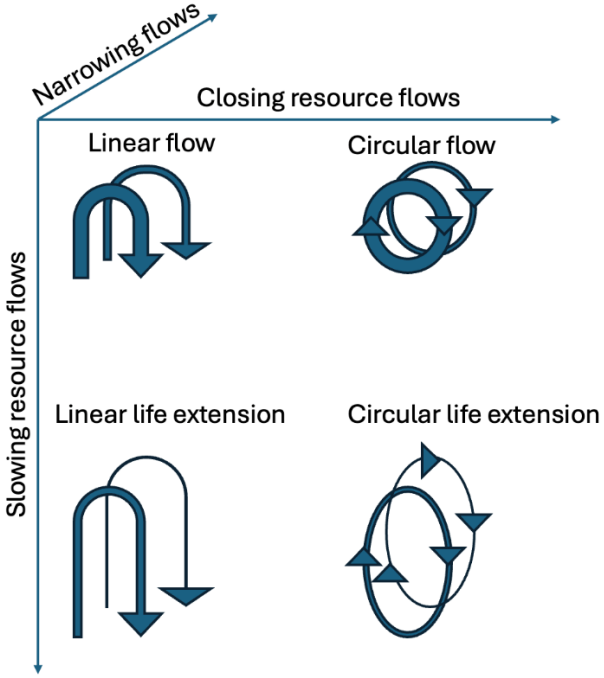

Figure 2 Visualization of the differences between linear and circular resource flows, adapted from N. Bocken et al., 2016

Of the resource flow management for CE, the closing of material loops appears to be the most popular, since organizations have been found to focus on reducing and recycling more so than repairing and remanufacturing when comparing initiatives undertaken in the transition to CE (Barreiro-Gen & Lozano, 2020). These findings were recently confirmed where large corporations ranked closing the loop on resources flows most popular, followed by narrowing and slowing the loop (N. Bocken et al., 2025). These findings are not surprising, since authorities have emphasized waste handling for longer.

2.3 Circular business models

CE is not only about resource flow management through product design strategies, it can also take on the task of transforming the underlying business model and associated values. CE has a dominant focus on environment and economy (N. Bocken, 2024) and CE specific business models should therefore be an integral part of CE. Circular Business Models (CBMs) focus on creating a circular value chain and stakeholder incentive alignment by making the value proposition, value creation and delivery, and value capture circular (Geissdoerfer et al., 2018). CBMs can be defined as

"business models that are cycling, extending, intensifying, and/or dematerializing 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 (dematerializing). (Geissdoerfer et al., 2020)

Several CBMs exist, but all appear to have substituting primary with secondary material, extending the lifetime of products and enabling second life, and material recycling (Nußholz, 2017) in common. The CBM terminology has a certain overlap with the resource flow management terminology, since entire business models can be built around these resource flows and associated design strategies for CE. For businesses to transition to CBMs, they must at minimum address the two critical aspects of resource strategy and innovation strategy from which six distinct CBMs can be identified (N. Bocken & Ritala, 2021). CBMs, like CE, can be influenced by enablers however, CBMs are also described as CE enablers themselves and will consequently be included in the section below.

2.3.1 Circular economy enablers

For CE to gain ground among businesses, it is of the essence to understand how CE practices are implemented and how they are enabled. That said, extant research focusing on CE enablers has nevertheless been limited and fragmented (Barreiro-Gen & Lozano, 2020; Sinha, 2022). Reviewing the growing academic literature on CE enablers shows that a definition is rarely provided by authors. Although no widely used definition of the term CE enabler was found, an enabler according to the dictionary is something that makes it possible for something to occur but is not in itself a goal or objective (Cambridge Dictionary, n.d.): ergo, it facilitates a change, transition, or event in the pursuit of a goal or objective. In academia, a CE enabler has been described as 'a factor facilitating and supporting the adoption of CE' (Rittershaus et al., 2025) or 'key success factors, drivers or indicators' (Yadav & Singh, 2024); or succinctly put as 'the "what" of CE' (Kirchherr, Urbinati, et al., 2023). In this dissertation, CE enablers are understood as factors facilitating and supporting the adoption of CE and thus reflect the definition by Rittershaus et al. (2025).

Despite the limited and fragmented research on CE enablers, it has been established that they vary in nature. Previously, research on CE enablers has largely focused on the macro perspective, like government policies and economic trends (Sinha, 2022). This is an interesting contrast, since most CE initiatives have been found to be implemented at the micro level (De Pascale et al., 2023). Macro level research found global climate pressure and ecological scarcity of resources to be the most significant enablers of the 30 circular supply chains identified (Lahane et al., 2021). At the micro level, at least seven CE enablers have been identified: 1) business model innovation, 2) knowledge management, 3) top management support, 4) organizational resilience thinking, 5) employee engagement, 6) technological advancements, and 7) organizational size (Sinha, 2022).

CE enablers can be categorized as internal or external to a business (S. Mishra et al., 2024). On the one hand, an enabler occurring externally to a business is categorized as an

external enabler (EE), because it occurs outside of a business and the business has either no or very little say in its manifestation. Internal enablers, on the other hand, are factors that businesses have full access to and controlling power over whether to enact or ignore. Even so, the division between external and internal is more of a nuanced scale rather than binary, and will be presented in more depth below.

2.3.2 External circular economy enablers

EEs facilitating and supporting CE have distinct characteristics, mechanisms and roles in the implementation of CE practices. EEs are available to benefit multiple emerging ventures, though they are not necessarily favorable to all ventures in the market. The External Enablement Framework is a novel framework for analyzing and understanding EEs in new venture creation and is detailed further below. In this novel framework, EEs are described as aggregate-level distinct external occurrences that hold the potential to play a crucial role in enabling entrepreneurial endeavors (Davidsson, 2015). Examples of EEs that have been studied include COVID-19 (Davidsson et al., 2021), blockchain (Chalmers et al., 2019), digital technologies (von Briel et al., 2018), AI (Davidsson & Sufyan, 2023), bioeconomy (Hinderer & Kuckertz, 2022), and CE (Nielsen & Hakala, 2023).

The EE framework was proposed for new venture creation but has subsequently also been applied to studies of existing organizations (Cestino Castilla et al., 2023; Nielsen & Hakala, 2023). The term EE was first introduced to research in 2015 and is therefore a relatively novel concept and framework, despite building on well-known constructs (Davidsson et al., 2021). The framework conceptualizes EEs through the exploration of their characteristics, roles and mechanisms, as well as how these impact entrepreneurial actions and outcomes (Davidsson et al., 2020). The characteristics of EEs are defined through their scope and onset, thus describing the nature of the EE. Mechanisms, on the other hand, describe the influence on entrepreneurial activity through opacity and agency intensity, while roles refer to the function that EEs have. This EE framework is particularly interesting when analyzing CE enablers, because the in-depth and holistic approach to understanding how enablers facilitate the implementation of CE practices supports transparency. Furthermore, as presented above, regulation and technology advancements continuously rank among the top CE enablers in research and the EE framework is therefore an interesting basis for investigating CE EEs.

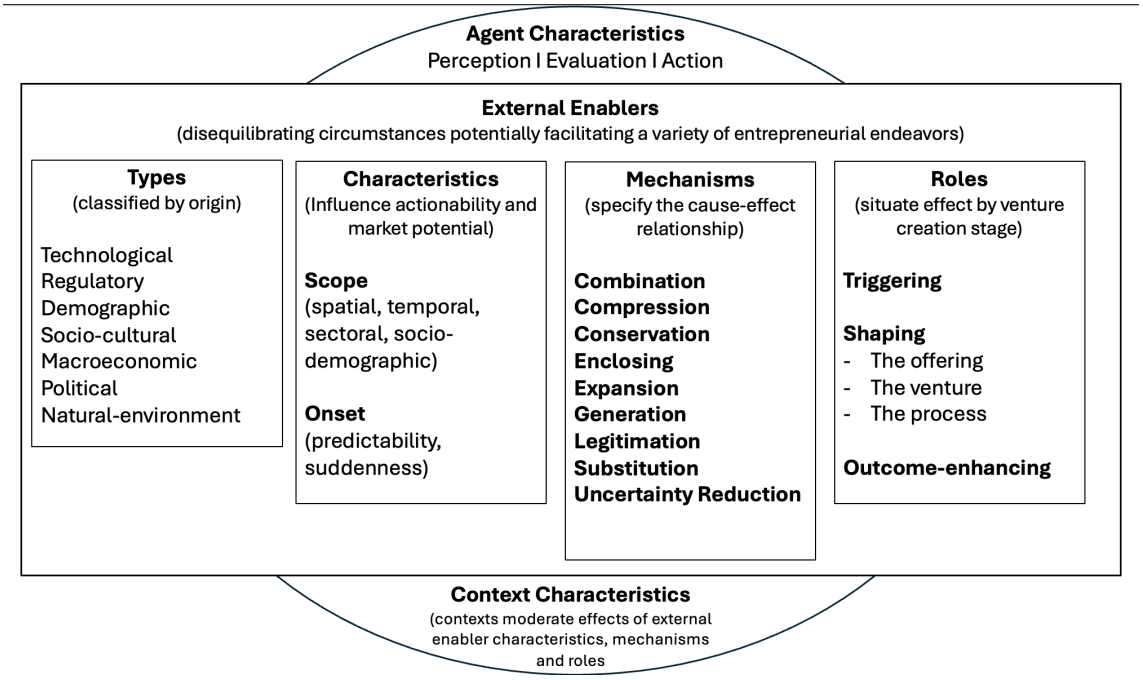

Figure 3 Visualization of the External Enablement Framework by Davidsson et al. (Davidsson et al., 2020)

2.3.3 Digital technologies as circular economy enabler

Another CE EE is a whole category of technological advancements under rapid development. Digital technology (DT) is an umbrella term referring to tools, systems and devices such as computers, software, and the internet, among others. An early study from 2016 found that technological developments like ICT "seem sufficiently mature" to support and accelerate large scale CE implementation (Lieder & Rashid, 2016). However, this view appears outdated, since technology development is a frequent and recurring topic among later research, which describes it as both enablers and barriers of CE (Antikainen et al., 2018; Ingemarsdotter et al., 2019; Wilts et al., 2021).

DTs can have a significant impact on production systems by improving resource efficiency in manufacturing and industrial services (Neligan et al., 2023).

Several digital CE enablers have developed through rapid technological advancements and are identified in the literature. The Internet of Things (IoT) is a digital CE enabler that supports servitized business models, maintenance, reuse and remanufacturing, as well as design for durability (Ingemarsdotter et al., 2020). Another digital CE enabler is digitalization, which has many potential benefits and uses. Digitalization enables CE through novel digital platforms, the ability to create new markets, reduce costs and increase efficiency, while also facilitating networking, collaboration and co-creation with

stakeholders (Antikainen et al., 2018). A third digital CE enabler is data-driven shared platforms that create technological and digital competitiveness, facilitate data accessibility and usability as well as business models by redefining products, processes and services (Atif, 2023). More specifically, the data-driven platforms enable technologies such as robotics, additive manufacturing, augmented reality, cloud computing and big data analytics (Atif, 2023). Furthermore, artificial intelligence (AI) can support the development of more circular properties, virtualizing business models and connecting products, as well as design for optimization and sharing (Aguiar & Jugend, 2022).

2.3.4 Internal circular economy enablers

Opposite and distinct from EEs are internal enablers. Internal CE enablers are factors that businesses themselves have control over, and they fall into multiple categories. Cultural CE enablers can include leadership, environmental culture, coordination and alignment with clients on CE values, collaboration to promote CE agenda, value chain engagement and the environmental awareness of top management (Sharma et al., 2024). CBM innovation can be a CE enabler by refocussing efforts away from a linear approach to optimization via a circular systems thinking approach (Nußholz, 2017). Collaboration, standardization, regulations, competitive costs and benefits, capabilities and resources, innovative applications and supply chain structure are all CBM enablers (Toorajipour et al., 2024).

For micro-, small and medium sized enterprises, it appears that internal enablers play a significant role in the implementation of CE practices. 15 of 19 identified CE enablers were found to pertain to the internal business environment rather than external environment (S. Mishra et al., 2024). As these enablers are linked, it may be argued that the internal enablers hold the function of deciding whether and how to act upon the CE enablers stemming from the external business environment. Internal CE enablers also include workforce skills, and six categories encompassing a total of 40 skills have been identified as necessarily present in order for CE startups to be successful: 1) business innovation skills, 2) operational business skills, 3) social skills, 4) systems skills, 5) digital skills, and 6) technical skills (Straub et al., 2023).

Although neither purely external or internal, circular supply chain enablers make up another meaningful category of enablers to describe. Supply chains are an essential yet challenging aspect of CE, due to the high complexity of reverse logistics that facilitate reuse, repairs, remanufacture, and recycling (Hussain & Malik, 2020). Circular supply chains may be defined as “the configuration and coordination of the supply chains to close, narrow, slow, intensify and dematerialize resource loops” (Geissdoerfer et al., 2018). Significant enablers of circular supply chains include collaboration and digitalization (Hussain & Malik, 2020).

As this state-of-the-art chapter has shown, CE enablers are varied, with various characteristics and levels. Furthermore, it can be difficult to categorize enablers due to

the holistic and complex nature of the topic. Some research describes supply chains as enablers, whereas others describe supply chains as the object to be enabled circularly. Likewise, CBM enablers can be both external or internal, and DT may be an enabler of CBMs and supply chains as well as manufacturing processes and product design. It is therefore of the essence to define the research gaps and design the associated studies appropriately to continue adding valuable insights to the research field.

3 Research design and methodology

This chapter explains the research design, philosophical underpinnings, and chosen methods relevant for the dissertation and its associated publications. The first section introduces the research design from an ontological and epistemological perspective. The second section presents and describes the various methods explored through the work with the publications included in this dissertation

3.1 Philosophical foundation and research approach

Research approaches vary, depending on research purpose and the research process begins with the clarification and examination of the philosophical assumptions of the researcher (Creswell et al., 2007). The clarification helps determine the appropriate means of data collection and analysis in accordance with the researcher's paradigm of inquiry. The paradigm of inquiry depends on the philosophical stance of the researcher, while the researcher's understanding of science can be described in terms of the philosophical views on ontology, epistemology and methodology (Denzin & Lincoln, 2018). These views impact which philosophical paradigm of inquiry a researcher follows (Erciyes, 2020). In short, ontology describes the nature of knowledge which can be understood along a continuum from subjective to objective, epistemology describes how a researcher assumes knowledge is obtained and can also be understood on a scale from subjective to objective, and methodology is the rigor with which one develops or tests knowledge (Howell, 2013).

The purpose of this dissertation is to explore how CE enablers facilitate the implementation of CE practices. The dissertation adopts a phenomenological ontological approach which favors thick data to understand situations and phenomena (Howell, 2013). Phenomenology is a relativist ontology (Denzin & Lincoln, 2018) where facts are not objective nor final truths; rather facts are dependent upon how individuals interpret the world and their context (Howell, 2013). From this perspective, human experience and reality are fundamentally linked and aligned with an interpretivist epistemology (Rosenberg & McIntyre, 2020). In this dissertation, the phenomenon under investigation is the transition to CE, which is increasingly prevalent in the business context. CE does not necessarily mean the same to all businesses and interviewees included in this thesis, though commonly agreed aspects exist, just as expressed in state-of-the-art. Ontologically speaking, enablers are not objectively there to be leveraged. Rather, they may have disequilibrating qualities that for some may be perceived as enablers and by others as barriers. Along the same line of thought, activities and practices undertaken may be judged by some as pertinent to CE, while others would classify them differently. This dissertation does not evaluate whether CE holds the key to a better future, nor whether one definition of CE is more appropriate than another. Rather, it examines how the path to CE is perceived and acted upon by businesses that consider CE to be a contemporary and contextual shift they need to address.

Furthermore, this dissertation is rooted in epistemological empiricism, in which knowledge is based on or justified by experience (Rosenberg & McIntyre, 2020). This subjectivist epistemology allows meaning to be co-created between the researcher and the interviewee (Denzin & Lincoln, 2018). Therefore, the empirical approach to this research aims to understand the experiences businesses have when engaging with CE and particularly how CE is enabled in their experience. From this epistemological viewpoint it is understood that this experience is a socially constructed reality, and all related research therefore is an interpretation and presented as such (Yazan, 2015). The empirical approach is used for all publications, and knowledge generation is based on semi-structured interviews in which the interviewer and researcher engage to interpret the experience of CE enablers by businesses.

The dissertation employs a qualitative research methodology, inspired by constructivism, critical thinking, and pragmatism. It is therefore understood that the researcher's presence and initiation of interviews will influence the way respondents act, think and respond. The researcher therefore acknowledges that historical and social events influence the present and that the results of any inquiry are subjective (Howell, 2013). Critical theory informs this study by challenging the status quo and recognizes that knowledge is shaped by values, and that theory continues to develop as values change over time (Howell, 2013). Constructivist and pragmatist philosophies have also inspired the RQs of this dissertation. The overarching RQ "how do CE enablers facilitate the implementation of CE practices" implies a qualitative research approach to explore the complex and multifaceted phenomenon that the path to CE represents. The rich insights following each of the four SQs together answer the overarching RQ from the perspectives of entrepreneurs, businesses in the food packaging industry, and CE startups utilizing AI. Qualitative research is essential for continued contributions to social sciences with its inherently interpretative nature (Gray, 2007). Furthermore, qualitative research is versatile with various inquiry strategies, traditions and approaches available (Creswell et al., 2007), offering quite a flexible yet not necessarily less rigorous way of conducting research. Qualitative studies are not bound by representative sampling, and the findings should consequently not be generalized without caution.

This research adopts inductive modes of inquiry in Publications II and III. Inductive reasoning is a method of drawing conclusions by going from the specific to the general. Therefore, in these two publications, conclusions emerge from specific observations, experiences and discovery (Gray, 2007). On the other hand, abductive reasoning is applied in Publications I and IV. Abductive reasoning is particularly useful when the focus is on discovering new variables or relationships, thereby especially helpful when refining existing theories rather than generating new ones (Dubois & Gadde, 2002), as was done in these two publications. By blending both inductive and abductive approaches, this dissertation builds knowledge from the bottom up.

Four qualitative research papers were designed to help answering the RQ. To address the first research gap – that in which a lack of framework for entrepreneurial ecosystems for CE entrepreneurs was identified – a qualitative in-depth case study was designed. This

case study gathered enablers identified in extant literature to develop a framework for CE-focused entrepreneurial ecosystems enablers. For the second research gap, which is the gap in knowledge regarding the relationship between CE enablers and changing business practices, two qualitative empirical case studies were designed. One study explored how EEs are utilized in the corporate transition to CE, while the other explored which activities change in the transition to CE. Both utilized the same set of data stemming from self-proclaimed CE frontrunners in the food packaging industry. Addressing the last identified research gap describing the limited literature regarding the use of AI in startups seeking to accelerate CE, a qualitative multiple case study was designed. This study explored the extent to which startups utilize AI for CBMs.

The four qualitative peer-reviewed scientific research publications seek to answer the overarching research question, each answering a separate sub question. The table below provides an overview of each publication. The context and cases are described in detail in the next section, and the methodological approaches, data collection and analysis are explained in the section after that.

Table 2 Methodologies utilized and objectives of the dissertation's four publications

	Publication I	**Publication II**	**Publication III**	**Publication IV**
Title	The circular water economy and 'the Seven Cs'	External enablers for the CE: A case study of the food packaging industry	The Changing Activities of Circular Economy Frontrunners: What do Food Packaging Manufacturers Do to Accommodate the Circular Economy?	Adaptation of Artificial Intelligence by startups for a Data-driven Circular Economy: Evidence from a multiple case study in Finland
Objectives	Identify necessary enablers for local sustainability focused entrepreneurial ecosystems to support CE-focused entrepreneurs	Understand how external enablers are used in the transition to a CE in the food packaging industry	Identify the activities that are changing within businesses claiming to be CE frontrunners in the food packaging industry	Understand how startups adapt AI to offer business model relevant for a CE
Methodology	Abductive	Inductive	Inductive	Abductive

3.2 Context and cases

Case studies are well-suited to social science research in general and contemporary business research in particular (Halinen & Törnroos, 2005). Enabling CE qualifies as a contemporary business topic as described in the introduction and background sections. An empirical case study approach was deemed a suitable research approach, considering the nature of the RQs and the philosophical basis they were formed on. The constructivist phenomenological basis of this thesis is the pursuit of a particularized understanding of the case, opposite more positivist approaches to case studies (Stake, 1995). Case studies are particularly valuable when the contextual conditions are included, because they may contribute richness to the case (Piekkari & Welch, 2018). Each publication therefore explicitly describes the contextual conditions.

Case studies can be of both single or multiple case nature. In single case studies, the unit of analysis is a single issue or concern and is characterized by the extensive contextual descriptions to foster the necessary understanding (Creswell et al., 2007). A multiple case study, on the other hand, brings together multiple cases to be studied jointly with the purpose of investigating a phenomenon by comparing and contrasting findings between the cases (Creswell et al., 2007). In this dissertation, there are three single case studies and one multiple case study.

Publication I is a single case study where the 'case' is the EcoSairila ecosystem, and it was studied between spring 2019 and summer 2020. The contextual conditions of this case study are connected to the Mikkeli Blue Economy Water Hub, alternatively known as EcoSairila, located in Finland. The unit of analysis is individual stakeholders within the EcoSairila entrepreneurial ecosystem. EcoSairila is a €100m investment CE business park with close ties between the business park, two local universities and other partners. All in all, this development creates an ecosystem attracting entrepreneurs focusing on CE.

Publications II & III are also single case studies, though the 'case' in this case study is the food packaging industry, represented by self-proclaimed CE frontrunners based in Finland. Thus, in this case study, the unit of analysis is the self-proclaimed CE frontrunner firms. The contextual conditions of the study can be described as highly regulated by national and regional authorities legislating on CE. Additionally, the industry is highly impacted by culture and public opinion, as well as technological development and competition. The data collected in this case study is based on confidential information: due to the competitive edge, the topic of 'enabling CE' was held within the companies. Food packaging plays a crucial role in keeping food safe and preventing food waste. Better food packaging solutions can reduce both packaging and food waste. Food packaging causes a significant amount of plastic waste annually and is expected to increase as food culture evolves (Tynkkynen et al., 2025). Not only does food packaging cause plastic waste, it also consumes large volumes of material on a global scale that is rarely recycled. The food packaging industry is therefore a compelling case to study in a CE context.

Publication IV is a multiple case study in which the units of analyses are five individual data-driven CE startups. Each of these five startups acts as an individual case, and the findings are compared and contrasted to further elevate the findings. The contextual conditions focus on AI and data-driven business models for a CE as presented in the state-of-the-art section. AI and other DTs are often portrayed as CE enablers and, in this study, are explored as such.

Several varying methods can be used in case study research (Thomas, 2011), and the four publications included in this dissertation have utilized multiple methods which will be presented in the following section.

3.3 Methods

This section introduces the research design choices made regarding the empirical parts of the dissertation. This dissertation presents and discusses the empirical studies with data collected through interviews. Each of the publications use a different method of analysis, considering each specific research question and the resourcs available. These will be presented and explained in the following sections.

3.3.1 Data Collection

The main data collection method applied in the four publications included in this dissertation is semi-structured interviews. Interviews were accompanied by meeting notes and, where applicable, online verification of background, dates, collaborations and innovations.

Interviews are the most common data collection method in the social sciences, and they are applied within a large variety of research fields (Denzin & Lincoln, 2018). Interviews can provide an in-depth understanding of the phenomenon being researched through interpretation and understanding of the interviewees' contributions, and will therefore be subjective in nature (Howell, 2013). Semi-structured interviews ensures that similar questions are asked of all respondents, though the order may differ, while allowing additional questions to arise from the researcher (Gray, 2007). The flexibility of allowing additional questions ensures better use of the knowledge production through dialogue and interaction between interviewer and interviewee (Denzin & Lincoln, 2018). This flexibility necessitates comprehensive background knowledge on the part of the interviewer (Howell, 2013).

In this dissertation, the background for all publications is the CE and CE enablers. Each publication has its own added empirical context: entrepreneurial ecosystems for Publication I, the food packaging industry and the EE framework for Publication II, the food packaging industry for Publication III, and DTs and CBMs for Publication IV. Consequently, the researcher already gained in-depth knowledge on the state-of-the-art of CE, CE enablers, and SD before the formulation of the interview guides and the open-ended questions it poses. Despite the interpersonal contact and context sensitivity of face-to-face interviews (Denzin & Lincoln, 2018), the COVID-19 pandemic influenced the nature of the interviews; therefore, many of the semi-structured interviews conducted were held online via Teams meetings. The interviewees were asked if they were comfortable with this method and all agreed they had already been introduced to and had become confident with online calls. All interviews were recorded for later transcription. The transcripts were transcribed word for word, though pauses and other linguistic cues were not included, as it is the content itself that is of primary interest in such studies (Gale et al., 2013). Following the transcription, a thorough familiarization phase occurred, in which the researcher re-listened and read through the data to ensure immersion. All interviewees were asked for consent before any recording commenced, and all interviewees agreed that their responses could be used for research aimed for publication.

All interviews were conducted in English, all interviewees were asked if they were comfortable responding in English, and all confirmed that they were.

The data collection for Publication I is based on 45 in-depth user-stakeholder interviews of 28 individuals from 10 types of organizations from the sustainable entrepreneurship ecosystem known as EcoSairila. The interview guide was based on the findings from a non-systematic literature review of CE enablers focused on ecosystems. From this literature review, seven enablers were identified and further refined into a multi-stakeholder framework. The interviews took place between spring 2019 and summer 2020, and lasted between 46 and 60 minutes each.

The same data set is used for both Publications II and III. The data set is based on eight semi-structured interviews which lasted between 25 and 60 minutes with an average length of 50 minutes. The interviewees all held roles with decision-making power for sustainability aspects of the company they worked for. The data collected during interviews were rarely verified outside the company through public information, due to the sensitivity of the innovation. Only time will tell whether new developments became viable in the market. The interview guide focused on questions of a sensitive character, and consent to interview was given, owing to agreed confidentiality and anonymity. The data collection for Publication IV is based on a series of semi-structured interviews with the founders and CEOs of five startups. These interviews, lasting approximately 60 minutes each, were conducted between February and April 2021. The interview guide was developed as based on a non-systematic literature review, and the participating startups were identified through industry organizations and news outlets.

Table 3 Overview of number and interviews and length of interviews for each article

	Number of interviews	**Length of interviews (min)**
Publication I	45	46-60
Publication II	8	25-60
Publication III	8	25-60
Publication IV	5	~60

3.3.2 Data analysis

Publication I follows a data-driven and theory-based thematic analysis method within a qualitative single case study approach, while Publication IV follows the same thematic analysis method, but in a multiple case study. Thematic analysis is a method identifying and analyzing patterns, and well-used when seeking to extract in-depth information from a data set (Braun & Clarke, 2006). The clusters of enablers identified through the non-systematic literature review were organized into a framework that was iteratively developed by going back and forth between theory and practice. Through this method, the clusters were conceptualized as 'the Seven Cs'. The Seven Cs refer to the seven enablers, all starting with the letter C, drawn out from the clusters. Publication IV also follows a thematic analysis method, but within a multiple case study approach. The NVivo 12 software was used as a tool for coding, aiding the iterative coding work by main authors. The thematic analysis of the interview transcript was initially undertaken using a node structure with highlighted sections of the interview questions template. These were refined during and after the NVivo 12 analysis to reflect where and when they appeared in the transcripts, and within the context of the objective of the original article transcript. After this first unit of analysis, the results were compared between the five case companies.

Publication II follows a descriptive framework analysis method, which is a particularly systematic approach to analysis within the content analysis family (Gale et al., 2013). Qualitative content analysis is a family of methods involving coding to identify patterns and themes (Cho & Lee, 2014). Descriptive framework analyses are used in research to generate themes where commonalities and differences are identified before relationships are identified, and they follow seven stages (Gale et al., 2013). The descriptive framework method is frequently used for thematic analyses of semi-structured interview transcripts that can then be compared and contrasted. The ability to generate themes regarding CE enablers allows a fuller picture from which knowledge generation stems. A code book was established by the author as part of the analysis process in which the types of EEs, mechanisms and roles were organized together with descriptive phrases extracted from the interviews. NVivo 12 was used as the coding tool and interesting findings were then drawn out for further exploration.

Publication III followed a content analysis method utilizing a data structure based on the Gioia description with 1st order concepts, 2nd order themes and aggregate dimensions (Gioia et al., 2013). Data collection and early analysis occurred simultaneously, though the analysis intensified over time. This dynamic and interactive approach to data analysis allowed optimization of the following data collection phases, based on the epistemological stance of the researcher and the guideline for qualitative case studies by Merriam (Yazan, 2015).

The table below sums up the methods and data utilized in the four publications.

Table 4 Methods, data, and level of analysis used in the publications

	Publication I	**Publication II**	**Publication III**	**Publication IV**
Method	Qualitative empirical case study	Qualitative empirical case study	Qualitative empirical case study	Qualitative empirical case study
Data collection	Semi-structured interviews	Semi-structured interviews	Semi-structured interviews	Semi-structured interviews
Data source	45 interviews of 28 individuals from 10 organizations	Eight semi-structured interviews, one interview from each business	Eight semi-structured interviews, one interview from each business	Semi-structured interviews with five startups, and documents shared by the startups
Analysis	Thematic analysis	Content analysis – descriptive framework	Content analysis	Thematic analysis
Unit of analysis	Ecosystem	Industry	Industry	Startups and small business
Case study	Single	Single	Single	Multiple

3.4 Research quality

One school of thought of case study methodology advocates for the use of both qualitative and quantitative sources of data in order to enable the fullest possible dataset when conducting case studies (Eisenhardt, 2021; Yin, 2014). Another school of thought however, argues that the exclusive use of qualitative data sources also enables the collection of a full set of data (Gioia et al., 2013; Merriam, 2002; Stake, 1995). This dissertation and its associated publications adhere to the latter school of thought, inspired particularly by Stake and Merriam rather than Eisenhardt and Yin. The school of thought

based on Stake and Merriam is more closely aligned with the constructivist epistemological worldview (Yazan, 2015) of this dissertation. Therefore, the research quality is understood as presenting an accurate view of a point in time where the CE enablers are studied as part of an ever-changing and multidimensional reality that businesses find themselves in. In Publications I, II and IV, the co-authors discussed the data and the interpretation of the data to present plausible explanations and describe findings with enough details to show how conclusions were made through interpretation. To this end, transparency and detailed accounts of the methods are of the essence (Gioia et al., 2013), and have been thoroughly described here and in each publication.

For publications II, III and IV, the data collected during interviews in particular were often not verifiable outside of the company through public information, as only time will tell whether new developments, technology, costs and pricing are viable solutions.

4 Results

This chapter summarizes the main objectives, methods, findings and contributions of the four publications included in this dissertation. The publications support the answering of the overarching RQ. The overarching RQ is as stated in section 1.2 "How do CE enablers facilitate the implementation of CE practices?"

Publication I develops a novel framework of enablers of circular ecosystems and applies it to a local case. Publication II investigates EEs in the food packaging industry and how circular frontrunners in that industry internalize these to transition to a CE. Publication III investigates the changing activities within businesses in the process to adapt to a CE. Lastly, Publication IV explores how startups offering CE related solutions utilize and adapt AI. The publications can be read in full as an appendix to the dissertation. The publications are presented in the aforementioned order.

4.1 Publication I: The circular water economy and 'the Seven Cs'

4.1.1 Main objective

While the literature on CE and sustainable entrepreneurship is increasing, little is known about institutional and societal transformations necessary for circular practices to be implemented. The objective of this publication was to examine how a supportive external environment for sustainable entrepreneurship can be created. Therefore, the aim of this study was to develop a framework for stakeholders such as regional development organizations and local members of research and education clusters when building an entrepreneurship-focused CE. Consequently, the study sought to answer the following research question: "What enablers need to exist within the local sustainability-focused entrepreneurial ecosystem to engage and support innovative CE-focused entrepreneurs?" The study served as an entry point for the dissertation by identifying and developing a framework of enablers for circular entrepreneurs.

4.1.2 Method and research context

This publication takes an abductive qualitative case study approach. The case is the Mikkeli Blue Economy Water Hub in Finland, also known as EcoSairila. EcoSairila is a business park with a €100m investment centered around the wastewater treatment and water reclamation plant, from which sustainable entrepreneurship endeavors are pursued. The data was obtained through interviews with stakeholders. The data analysis is based on 45 in-depth user-stakeholder interviews with 28 individuals from 10 types of organizations within EcoSairila, the local sustainable entrepreneurship ecosystem. The interviews took place between spring 2019 and summer 2020 and lasted between 46 and 60 minutes each. The analysis uses a data-driven and theory-based thematic analysis method within a qualitative single case study approach developing the 'Seven Cs' framework through theory-practice iterations. Thematic analysis is a method well-used

when seeking to extract in-depth information from a data set (Braun & Clarke, 2006). The clusters of enablers identified through the non-systematic literature review were organized into a framework which was iteratively developed by going back and forth between theory and practice. Through this method, the clusters were conceptualized as 'the Seven Cs'. The Seven Cs refer to the seven enablers, all starting with the letter C, drawn out from the clusters. The NVivo 12 software was used to code aiding the iterative coding work by the main authors. The thematic analysis of the interview transcript was initially undertaken using a node structure with highlighted sections of the interview questions template. These were refined during and after the NVivo 12 analysis to reflect where and when they appeared in the transcripts, and within the context of the objective of the original article transcript.

4.1.3 Main findings

Through an initial literature review seven enablers for CE-focused ecosystems were identified and eventually conceptualized as the 'Seven Cs'. The seven enablers are 1) competencies available, 2) customer availability, 3) connector availability, 4) collaboration, 5) coordination, 6) culture, and 7) a center, either physical or virtual. The findings stress the importance of especially conscious, collaborative stakeholder support and ecosystem coordination for creating supportive and engaging sustainable entrepreneurial ecosystems. The findings are presented in the below table, detailing which literature identified each of the seven enablers as well as linking the enablers to the case study data where the enablers became apparent. The table also provides an overview of the background for the novel 'Seven Cs' framework. The framework was tested on a single startup within EcoSairila to extend the contribitions to practitioners as well.

Table 5 Summary of findings and background for the Seven Cs framework (O'Shea et al., 2021)

CE enablers	**Relevant literature on enablers**	**Key findings in the case study**
Competence availability: 1) of entrepreneurs themselves, and 2) through the system	Especially various 'sustainability competences' (Eizaguirre et al., 2019), technologies, knowledge, information and technical skills, enabling 'advanced technical' options for their business (Rizos et al., 2016; Bechtel et al., 2013).	1) Often acquired outside the region; sustainability linked to pre-existing values; information networking; region attractive for living. 2) Key development agency support; but lack of innovation expertise.
Customer availability	Industrial symbiosis (Chertow, 2007) and especially focusing on green values and practices	Already B2B-green business especially fitting EcoSairila and

	of consumers (Gleim et al., 2013).	overall supposed B-C green customer potential.
Connector availability	Conversants (Shane and Cable, 2002) experiences business people (Mason and Brown, 2014), researchers (Haarla et al., 2018), third-party, broker, and facilitator (Gliedt et al., 2018; Howells, 2006; Kanda et al., 2018; Kivimaa et al., 2019).	Some connector support already existing, such as a development agency, city council, university consortium.
Collaboration inside the ecosystem	Increases productivity and reduces costs (Acs et al., 2008); collaborative sense-making (O'Shea et al., 2019); partnerships (Wooi and Zailani, 2010), contacts to customers (Rizos et al., 2016) and distributing ideas in the ecosystem (DiVito and Ingen-Housz, 2019).	Identified as something which is needed more, but it has the classical problem of investment need without the certainty of useful outcomes, trust needs to develop. Support is available as connectors host meetings, gathering people, organize networking hubs.
Coordination: system level fitting the parts of the ecosystem together	Shared goals, and policies boundaries and governance (Hakala et al., 2019); efficiency and coherence (Jacobides et al., 2018); co-sensemaking and co-integration (O'Shea ey al., 2019).	The wish is to get an actor to take a more formal role in coordinating various parts of the ecosystem. The current system is informal and 'facilitated' by the city council through 'nudging' activities.
Culture: an innovation-oriented and sustainability-willing or -demanding culture	Both entrepreneurial culture-(Malecki, 2018) and general culture- promoting circular economy (Mathews & Tan, 2011) and shared sustainability orientation amongst the stakeholders (O'Shea et al., 2019; DiVito and Ingen-Housz, 2019).	There already exists a sustainability-willing culture. EcoSairila is developing the brand image as an EU centre of water excellence; it has persuaded some entrepreneurs to establish their businesses in the CE park.

Centre: a physical and virtual space	Unites various supporting resources, enhances the supportive culture, and makes related services more accessible for entrepreneurs (Spigel, 2016).	EcoSairila is growing as a physical centre of excellence for water circularity and research, but a clear and visible centre is needed for creating access for specific resources.

4.1.4 Contributions

The publication offers a contribution to fill the research gap related to the establishment of a supportive and engaging environment for entrepreneurs within sustainable entrepreneurial ecosystems. The theoretical contribution of this study is mainly the 'Seven Cs' framework. The 'Seven Cs' framework is based on seven enablers found crucial for entrepreneurs to pursue circular endeavors. The 'Seven Cs' framework is the first attempt to unite enablers identified within CE-focused ecosystems and regional CE development into a theoretical and practical model. Practically, the framework can be used both as a starting point for the development of sustainable entrepreneurship ecosystems as well as a reflection of the development status. This framework may be of value to entrepreneurs as well as all potential stakeholders and facilitators of sustainable ecosystem developments.

4.2 Publication II: External enablers for the circular economy: A case study of the food packaging industry

4.2.1 Main objective

This publication explores how EEs in the food packaging industry influence the transition to a CE. This is one of the first attempts to bring together literature on EEs of entrepreneurship with CE. The research explores the effects of multiple EEs occurring simultaneously empirically as prior studies, focusing on studying the effects of a single EE at a time. The study sought to answer the following research question "How is the food packaging industry leveraging EEs during the transition to a circular economy?"

4.2.2 Method and research context

This study takes an inductive qualitative case study approach to explore EEs for CE in the food packaging industry. The case includes both incumbents and startups identified through a thorough identification process. The selected businesses all fulfil the following three criteria: 1) describes themselves as CE frontrunners, 2) are headquartered in Finland, and 3) operate in the business-to-business (B2B) market as producers of food packaging. The semi-structured interviews were conducted with individuals whose roles

directly influence sustainability-related decision-making and the implementation of related activities. The interviews lasted between 25 and 60 minutes with an average length of 50 minutes. This qualitative study follows the descriptive framework analysis method (Gale et al., 2013) for content analysis. The descriptive framework method was used to compare and contrast the findings and thus to generate themes with an established procedure.

4.2.3 **Main findings**

The findings in this publication suggest that packaging manufacturers react to four types of EEs linked to CE. The four types of EEs are 1) political (voluntary sustainability), 2) regulatory (legislation such as EU Green Deal and the Plastic Packaging Tax), 3) sociocultural (customer and consumer demands) and 4) technological (incremental and radical developments). Furthermore, it appears the industry is moving convergently and leveraging a relatively small range of mechanisms that shape the existing business. The five mechanisms leveraged are 1) combination, 2) generation, 3) conservation, 4) resource substitution, and 5) resource expansion. Lastly, the data revealed the activation of three roles that impact new venture creation: 1) shaping, 2) outcome enhancing and 3) triggering. A visual presentation of the findings described can be found below. The figure shows the relationship between the four EEs, five mechanisms and the three roles. All four EEs can impact the resource expansion mechanism, which in turn shapes the business. The regulatory and socio-cultural EEs impact the conservation and resource substitution mechanisms, which in turn may enhance the outcome of the business. The socio-cultural and technological EEs impact the conservation, combination and generation mechanisms, which in turn may trigger new business.

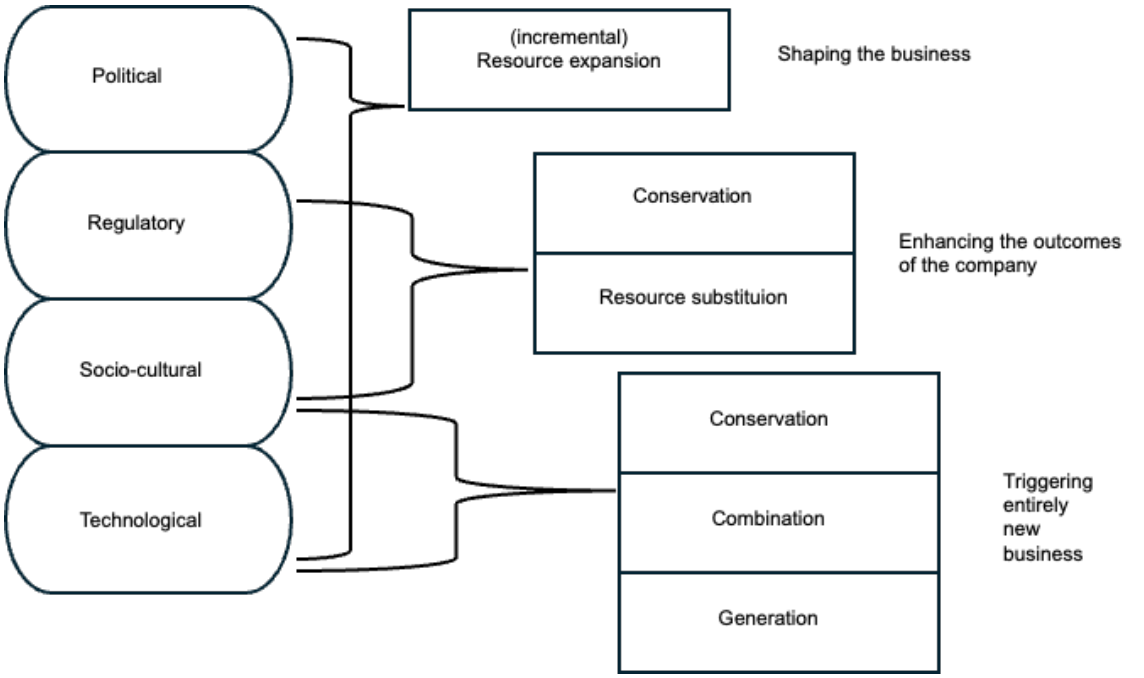

Figure 4 CE external enablers prompt various mechanisms that in turn shape, enhance or trigger new business

4.2.4 Contributions

The study contributes to CE research and practice and specifically helps understand and advance the framework of EEs. The study identifies an important boundary condition for regulation as an EE, since additional EEs seem to drive business venturing towards more advanced CE solutions. The study is also among the first to lend empirical credence to the effects of multiple EEs occurring simultaneously, jointly found to be a single CE external enabler. Furthermore, our findings add empirical credence to the conceptual claims of the EE framework (Davidsson, 2020), suggesting that the same EEs can activate various mechanisms and play different roles, depending on the agent.

4.3 Publication III: The Changing Activities of Circular Economy Frontrunners: What Do Food Packaging Manufacturers Do to Accommodate the Circular Economy?

4.3.1 Main objective

The third publication focuses on the circular process implementation, more specifically the corporate-level activities in the transition from a linear economy to a CE. Pressures from policy changes and consumers force the food packaging industry to evolve, prompting an increasing demand for knowledge on best practices around circular packaging. This research addresses this need and explores how the activities of self-proclaimed CE frontrunners in the food packaging industry are changing as they move towards a CE. The aim is to explore data from international food packaging industry firms to narrow the knowledge gap on managerial activities supporting and accelerating a CE. The research question is: "What activities are changing in CE frontrunner firms implementing CE-related innovations in the food packaging industry?"

4.3.2 Method and research context

This study employed an inductive qualitative case study approach to examine how CE frontrunners in the food packaging industry drive innovation to advance the CE. Data was collected through semi-structured interviews and analyzed following a content analysis method that utilized a data structure based on the Gioia description with 1st order concepts, 2nd order themes and aggregate dimensions (Gioia et al., 2013) as shown in the table below. The semi-structured interviews lasted between 25 and 60 minutes with an average length of 50 minutes.This study of frontrunners in the food packaging industry is based on empirical data from both incumbents and startups identified through a thorough identification process. The selected firms all fulfilled the following three criteria: 1) according to their own assessment, they were CE frontrunners, 2) they are headquartered in Finland yet operate internationally, and 3) they operate in the business-to-business (B2B) market as producers of food packaging.

Table 6 Coding and data structure based on Corley and Gioia (Corley & Gioia, 2004)

Data source	Exemplary quotes	1st order concepts	2nd order themes	Aggregate dimensions
Semi-structured interviews with managerial roles with responsibility for sustainability	Both customers and regulations are pushing us very strongly toward circularity, particularly in certain parts of the market. And we see this clearly as a factor where we can differentiate and co-develop and co-create and also sort of strive to create the best innovation in the market. (C5)	Co-development and co-creation for improved innovation	Collaboration	Business practices
	We are investing in things like paper lids for paper cups and fiber lids for paper cups. Those are innovations we are moving toward and working with others in the supply chain to achieve. (C6	Collaboration along the supply chain		
	… that is also a partnering concept, so we are not doing it by ourselves but in a partnership. Originally though, it was about utilizing waste back in the day, which has then developed continuosly. (C8)	Partnerships rather than single-company innovation		
	We now have an app to calculate your packaging carbon footprint, and it gives you alternatives with lower carbon, lower water usage, and lower everything. (C2)	Awareness raising	Business development	
	It is a way of getting much closer to your customers and really understanding … what they need and really truly co-create and co-develop. I think some of those divisions that have worked longest with their customers to create more circular business models and value chains have found this extremely valuable for business development purposes and customer relationship enhancement. (C5)	Improved customer relationship		
	We are also working on bringing in new material combinations and innovating possible new solutions and processes. (C1)	Material combinations and new solutions and processes		
	Another one is a big focus, not just on waste but on our biowaste raw materials … when we think about packaging materials, there is a strong drive to move away from fossil fuel-based materials into renewable materials, and this is a big driver for us. (C3)	Switch to renewable materials	Material innovation	Packaging materials practices
	The driving force behind our company was the need to replace plastics, and plastics, in many cases, are anything but circular. (C4)	Replace plastics as a material		
	Our plastic product for meat must be sealed. Now customers think this product should be more environmentally friendly, so we have to replace plastic packaging with cardboard. (C7)	Replace plastics with cardboard		
	When it comes to designing and redesigning packaging solutions, one aspect, for example, utilizing the correct minimum amount of material, has been going on for years now. (C1)	Reducing amount of material used for same functionality	Material efficiency	
	We now have a process where we take the waste back into the machine. Basically, this is a slight shortcut in the process, but it was happening. We retain the stuff. (C2)	Recycle post-production scrap as raw material		
	The entire industry, especially the Nordic paper industry, had invested significant amounts of money in innovations to move toward reducing the amount of polymer used. (C6)	Reduction in raw material		
	Turning packaging into mono-materials, not strictly for recyclability but downgauging. (C2)	Recyclability	Material recirculation	
	All our materials are developed so you can recycle them with paper board or packaging waste. That is another thing that differentiates ours from many other new materials; you need to create some kind of closed-loop system in order to recycle them. (C4)	Recyclability		
	Circularity for our product generally means recyclability; it can mean compostability, but the easy one to look at is recyclability. (C6)	Recyclability and compostability		

4.3.3 **Main findings**

The findings suggest that a number of activities are changing in the transition to CE among CE frontrunners in the B2B packaging industry. These activities can be grouped into the following five themes: 1) collaboration, 2) business development, 3) material innovation, 4) material efficiency, and 5) material recirculation. These groups of activities impact one another through interdependent relationships, as marked by the arrows in the figure below. Collaboration is the central theme among the findings and signifies a much closer relationship with both customers and suppliers along the value chain. Collaboration directly impacts material recirculation, material innovation, and business development through demands and requests stemming from the close(r) relationship-based value chain partners. Business development is more focused on internal skills and decision-making, though heavily directed by collaborations, material efficiency, material innovation and material recirculation via demands, requests, and innovations. On the other hand, business development appears to only impact material recirculation through supportive measures such as raising awareness, various material combinations, and new solutions. Material innovation activities are shifting away from fossil-fuel based plastics and replacing it with materials from renewable and bio-based resources, or replacing plastics altogether.

Material innovation is influenced by collaborations along the value chain as well as by material recirculation demands. Material recirculation activities are focused at improving recyclability, and in some cases compostability of products and materials. Collaboration along the value chain and business development activities influence the direction and level of ambition in material recirculation-themed activities. Material efficiency reduces the amount of raw material usage and is mostly separate from the other activities, though it may influence business development activities.

Another interesting finding is that although some activities change in the transition to CE, some also stay the same but are rebranded as CE practices. One theme of the activities that stayed the same but were rebranded for the CE transitition is material efficiency. The material efficienct activities shared by the interviewees commenced independently of EEs and before the the CE transition started, in order to reduce material costs. Material efficiency is a crucial aspect of CE, and thus the rebranding of the activity also in line with CE; however, the rebranding from cost optimization to CE initiative was interesting to uncover.

None of the businesses were engaged in eliminating single use packaging waste nor extending the lifespan of packaging.

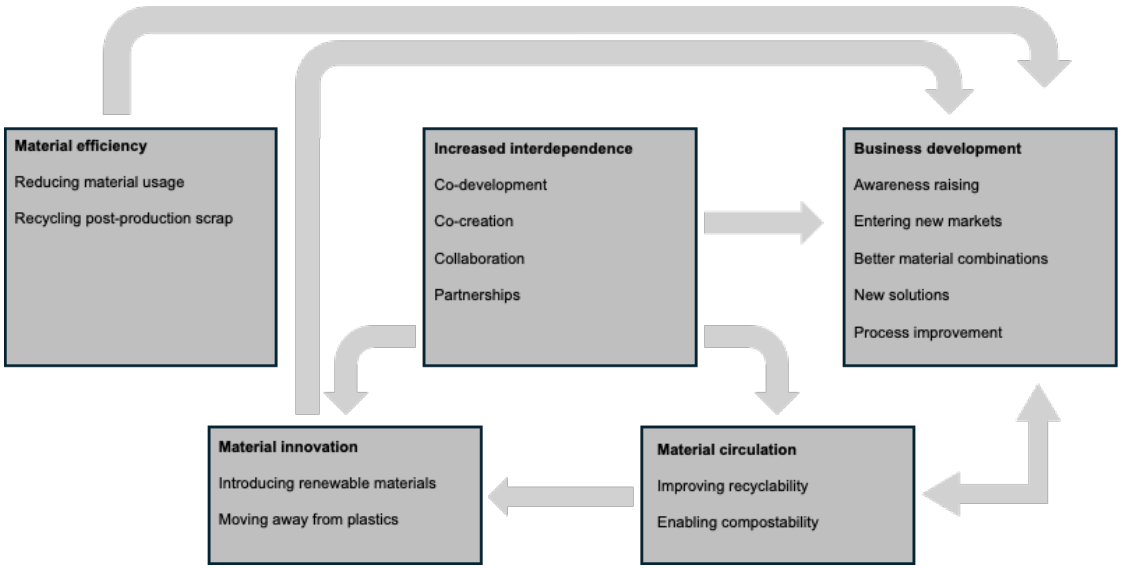

Figure 5 Summary of the relationships between the five types of changing activities

4.3.4 Contributions

This study explores the activities changing among self-proclaimed CE frontrunners in the B2B food packaging industry, thereby expanding the understanding of enablers for the

adoption and implementation of CE. The study contributes to the literature on CE, providing insights on the practical implications for an acceleration of CE implementation. The findings demonstrate which activities businesses transitioning to CE are changing in order to be CE frontrunners in their industry. The main contribution of this publication relates to the lack of attention paid to how corporate innovations contribute to the CE transition, despite innovation being critical for a transition to CE. It is, therefore, essential to explore how CE and innovation intersect in practice to reduce the knowledge gap and understand the nuances of how businesses can advance the transition to CE. These insights complement the literature intersection of CE and innovation through a lens of external enablement.

4.4 Publication IV: Adaptation of Artificial Intelligence by startups for a Data-driven Circular Economy: Evidence from a Multiple case-study in Finland

4.4.1 Main objective

The final publication focuses on AI as an enabler of CBMs. The objective of the study was to investigate the adaptation of AI in circular startups, focusing on data-driven business models. The aim of the publication was to identify how startups are adapting AI to offer data-driven business models for CE solutions by asking: “What is the current implementation of AI in data-driven CBMs by startups”?

4.4.2 Method and research context

This study takes an abductive multiple case study approach to explore how AI is utilized in CBM startups. The study is based on five startups providing data-driven circular solutions in Finland. It employs a thematic analysis of semi-structured interviews to identify the key AI technologies implemented by startups to accelerate CE solutions. The thematic analysis gathered theoretical components from relevant literature and created a model with which the data was analyzed. The analysis is based on data from in-depth semi-structured interviews with either founders or CEOs of each of the case companies, supported by other types of data collected to deepen the understanding of the case. The interviews lasted approximately 60 minutes each.

4.4.3 Main findings

The results suggest that data is at the core of circular solutions and AI has significant potential in enabling CE. All the interviewed startups highlighted the essential role of data in their solutions, and that data utilization enables their products and services to align with CE objectives. All solutions made use of digital tools; however, only two companies utilized AI technologies, whereas the remaining three companies mentioned they

continued to use traditional software solutions but recognize the potential of AI in many solutions. The below table presents a summary of the findings.

Type of data	Digital technologies	Utilization of AI technologies
• Data on different parts of food products lifecycle • Data on individual land-based farming such as data on the type of soil, nutrients, fertilizers, fuel	• Azure cloud-based technology • Modern interface coding • Conventional software development technologies • Database integrations between different operators and APIs	• Not yet • Huge potential for machine learning algorithms and artificial intelligence in company's product roadmap • Requires having bigger data pools
• Data on lifecycle and durability of textile products • Data on resale price • Data on quality of the product • Data on material • Process data	• Digital platform • Machine learning for databases • AI for pricing automation • AI for matching products • Google analytics • Cloud-based platforms • RFID tags for products and packs	• yes
• Data on lifecycle of products • Data on waste • Data on sales	• Big data • Conventional software development technologies	• Not yet • High potential for AI • Potential of QR codes that holds expiry dates
• Data on lifecycle of packages • Data on logistic processes	• Digital platforms • In-house developed system • Conventional software	• No • Potential of automated inspection by machine vision • Potential of utilizing sensors to track real-time data on logistics
• Digital phenotypical data on plants in various plots • Data on conditions, disease symptoms, number of grains in plots • Data on agri-food value chain	• AI-based analytics • Mobile apps • Algorithms	• Yes • AI • Machine vision • Deep learning

Figure 3 Type of data, digital technologies, and utilization of AI in circular solutions identified

4.4.4 Contributions

This multiple-case study explores how circular startups have adopted AI to utilize data-driven business models. This publication contributes to the growing research at the intersection of CE, entrepreneurship and digitalization. The findings demonstrate how two case companies have started using AI and three other case companies understand and promote the potential of AI but have not yet started using it, though they use other digital technologies. The main contribution of this publication is bringing empirical evidence to the field, showcasing the rate of adoption and implementation of AI for CBMs.

5 Discussion

Authorities, organizations and the general public increasingly focus on adopting solutions to global environmental challenges. CE holds potential as one of the ways to address environmental challenges by supporting the development of a new economic system in which waste is eliminated, and materials are continuously cycled back as raw material. Simultaneously, CE research brings novel insights with a high number of new publications every year (Kirchherr, Urbinati, et al., 2023). Despite this increase in new research and the focus on accelerating solutions to global environmental challenges, the Circularity Gap report details how implementation of CE practices is lacking, with less than 10% of all materials being circulated globally (Circle Economy, 2024). The dissertation seeks to contribute to our understanding of how CE enablers facilitate the implementation of CE practices. The findings contribute both theoretical and practical insights for anyone seeking to accelerate the implementation of CE.

In short, this dissertation identifies CE enablers in a local entrepreneurial ecosystem, in the food packaging industry and among CE startups. This was done by conducting interviews with ecosystem stakeholders in the local CE entrepreneurial case, EcoSairila, and with B2B actors in the food packaging industry. It then continues to explore how CE EEs affect businesses, and which activities change in the transition to CE by uncovering which mechanisms are leveraged and business practices changed due to CE enablers. Lastly, it explores digital tools leveraged as CE enablers adopted by CE startups. These aspects are further explored and key results discussed in the following sections. This chapter summarizes the findings by answering the initially posed RQ and discussing them in relation to extant literature as presented in the theoretical background chapter.

Section 5.1 summarizes the main findings from the four publications and elevates these to discuss them within the larger context of CE enablers.

5.1 How do CE enablers facilitate the implementation of CE practices?

The purpose of the dissertation to better understand how the implementation of CE practices is facilitated by CE enablers. The purpose was addressed by conducting four individual studies. The four studies identified a total of 14 CE enablers. The studies furthermore explored how the enablers facilitate the implementation of CE practices by also identifying and discussing the changing practices and deep-diving into the adoption of a particular CE enabler, AI. The following 14 enablers were identified as part of this dissertation: 1) competencies availability, 2) customer availability, 3) connector availability, 4) collaboration, 5) coordination, 6) culture, 7) a center, 8) political, 9) regulatory, 10) sociocultural, 11) technological, 12) AI based analytics, 13) mobile apps, and 14) algorithms. The 14 enablers are a mixture of enablers found at the macro and micro level, which will be discussed in sections 5.1.1 and 5.1.2.

The discussion in the next sections sheds further light on them and how they are leveraged, first by discussing the CE enablers at macro level and then the CE enablers at the micro level. Furthermore, two categories of practices changing in the transition to CE were identified and discussed: business practices and material practices. The RQs and key findings of each publication are summarized in the table below.

Table 7 Research question and key findings for each publication

Publication	Sub research question	Key findings
I	What enablers need to exist within the local sustainability-focused entrepreneurial ecosystem to engage and support innovative CE-focused entrepreneurs?	Identified seven CE enablers and developed a framework for theoretical and practical use based on the identified CE enablers.
II	How is the food packaging industry leveraging external enablers during the transition to a circular economy?	Four enablers push packaging manufacturers towards CE by activating five mechanisms that in turn impact new venture creation in three distinct ways.
III	What activities are changing in CE frontrunner firms implementing CE-related innovations in the food packaging industry?	Five themes were identified that can be grouped into two: Business practices and Material practices, highlighting the activities CE frontrunner companies change in the transition to a CE.
IV	What is the current implementation of AI in data-driven CBMs by startups?	Two startups utilize AI (machine learning and analytics), while three startups recognize the potential for AI in the future.

5.1.1 CE enablers change status quo and prompt individual responses

The findings of this dissertation suggest that CE enablers at the macro level facilitate the implementation of CE practices at the micro level by changing the status quo of conducting business. CE enablers at the macro level, however, do not just create a 'positive' change to the status quo, they create a change that needs an internal action and thus induces a decision-making process within businesses. The CE enablers thereby

create a new reality that allows or encourages individual businesses to develop solutions to the best of their ability. The changes to the market equilibrium caused by CE EEs instigate a variety of internal responses from the impacted businesses concerned.

How businesses choose to respond to CE enablers at the macro level appears to depend on the internal capabilities (Straub et al., 2023) and senior leadership beliefs (Sharma et al., 2024) specific to the businesses impacted. Internal capabilities, or competencies, were also identified as a CE enabler in the case of EcoSairila discussed in Publication I. Competencies are also indirectly mentioned by interviewees in Publication IV, where startups are aware of the potential of AI for their businesses, yet only two of the five startups utilize AI. Publications II and III address competencies through increased collaboration with value chain partners, stating that knowledge-sharing improves competencies.

That CE enablers can change the status quo is consistent with the External Enablement Framework (Davidsson et al., 2020), which states that a change to the market equilibrium may be beneficial to some but not all affected parties (Davidsson et al., 2020). Also, the mechanisms activated fit the External Enablement Framework, but this is where the internal capabilities and leadership of each business differentiate the mechanisms leveraged. In this dissertation, the data is collected from businesses that observed and acted upon the CE macro enablers already seeking to gain competitive advantage, or even to stay in business (Nielsen & Hakala, 2023). Explicitly tying macro level CE enablers with internal CE enablers as was done in Publications II, II and IV seem to be novel contributions to the literature on CE enablers. For example, new regulation is one way the market equilibrium can change, and prior studies have also noted the importance of regulatory measures acting as CE enablers (Min et al., 2024; Toorajipour et al., 2024). CE-enabling regulations may be of both a prohibitive and incentivizing nature, such as the Packaging and Packaging Waste Regulation (European Commission, 2018). This specific piece of regulation is, on the one hand, building on the end of single use plastics and, on the other, promotes recycled content. The prohibitive part of the regulation appears on the surface to leave little room for packaging producers. However, the results of this dissertation show that some packaging producers seek to replace the plastic material in a product that is affected by the prohibitive aspect of the regulation by developing or purchasing alternative materials. Others, however, seek to develop novel solutions providing a new means to the same end. Others again already have materials adhering to the "no plastic" part of the regulation and apply this material to new products affected by the prohibitive regulation, thus entering new markets with a competitive edge. Specific material innovations depend on the products and industry in which the material is utilized, though switching from non-renewable to renewable materials or circular materials is the objective of CE (Aguiar & Jugend, 2022). Prior research found recycling and end-of-life handling were the most prominent strategies adopted in the EU (Sundqvist-Andberg & Åkerman, 2021), which is in line with the findings in this dissertation. However, a clear causal relationship could not be established, because these strategies for recycling and end-of-life handling have also been in focus prior to the existence of this particular regulation, through other regulatory measures.

Therefore, in conclusion, when CE EEs change the market equilibrium, they appear to enhance the involvement of businesses transitioning to CE by inducing active decision-making. When regulatory measures dictate a move to (more) circular solutions, businesses in the food packaging industry collectively acted as intended, yet each with distinct individual solutions based on internal decision-making processes. Perhaps CE EEs facilitate the implementation of CE practices by giving direction to the internal CE enablers that are dependent on the unique business set-up, values, market position, financial abilities, and employee skills, etc. However, this should be further investigated through future studies before reaching any conclusion, as it is outside the scope of this dissertation.

5.1.2 DTs and technological advancements accelerate CE implementation

Another key finding of this dissertation is that DTs and technological advancement appear to accelerate for facilitating the implementation of CE practices. Of the 14 identified CE enablers in this dissertation, DTs and technological advancements have the potential to accelerate the majority of non-tech CE enablers, including competency availability, customer availability, collaboration, coordination, political, and socio-cultural enablers. The acceleration of these other CE enablers may take varying formats. DTs support improved communication channels, digitization of data, accessibility and sharing of data, faster feedback loops, and less need for physical and expensive prototyping. Technological advancements improve processes through speed, improved safety and testing, as well as less energy consumption and traceability.

Some interviewees mentioned DTs and technological advancements as relevant for their internal decisions and processes; yet, after careful analysis of the combined data of all four publications, the majority of the implemented CE practices would have been implemented significantly more slowly without DTs or technological advancement. The analyses show that data is at the core of novel circular solutions, and AI has significant potential in enabling CE, thereby confirming findings in prior literature (Atif, 2023; Ingemarsdotter et al., 2020; Voulgaridis et al., 2024; Wilts et al., 2021). However, this dissertation adds a new perspective by suggesting that DTs and technological advancement may be accelerators of other CE enablers. Without DTs and technological advancements, the transition to a CE would be slower, less cost-effective, and more resource-intensive. Economic incentives have been identified in prior research as one of the top five CE enablers at the meso-level (Min et al., 2024), and this study extends this finding to the micro-level. This finding also echoes the editorial by Kirchherr et al. bluntly stating that digitization may be the most under-estimated CE enabler for circular disruption (Kirchherr, Bauwens, et al., 2023).

CE practices implemented as based on DTs and technological advancements are abundant. For example, co-development and co-creation are based on digital communication technologies, easing collaboration between actors in the value chain. Also replacing materials and testing new product developments were presented as difficult to achieve without the newest technology. Collaboration along the value chain both in

internationally operating businesses and for local startups is also improved through digital technologies. DTs allow customization and accurate processing of large data sets in a short amount of time, thus providing near-instant feedback between and across value chains, which lays the basis for enhanced collaboration between value chain partners. The startups providing data for this dissertation highlighted the essential role of data in their solutions, and that data utilization enables their products and services to align with CE objectives. These findings align with prior research stating that processes become more efficient, minimize waste, extend product lifetimes and reduce transaction costs (Antikainen et al., 2018). Moreover, digital and technological CE enablers also create the basis for a multitude of CBMs like platformitization and servitization (Vecchio et al., 2024).

This finding may be limited to countries and regions with similar lifestyles as those of Northern Europe. In this dissertation, the data is collected among businesses based in Finland where DTs and technological advancements are used in industry to mitigate the effects of over-consumption and wasteful lifestyles. Over-consumption and wasteful lifestyles may occur less frequently or at a smaller scale in countries less inclined to such lifestyles, though manufacturing industries are also found in such regions, and thus the findings from this thesis may apply. The findings should therefore be transferred with caution.

Although all the startups interviewed made use of digital tools, only two companies utilized AI technologies. The remaining three companies mentioned the continued use of traditional software solutions, but recognize the potential of AI in many of the latter. The larger businesses interviewed hinted at AI usage in the future, but at the moment they base their future on technological adaptation and digital communication technology rather than AI. Therefore, in conclusion, it appears that DTs and technological advancements have the ability to accelerate other CEs, yet at the same time, or perhaps because of this, they may be the most under-estimated CE enabler.

6 Conclusions

CE influences how businesses (can) operate. CE enablers affect the market equilibrium which businesses (can choose to) act upon. Whether and how businesses act upon CE enablers depends on each businesses' values and understanding of CE. This dissertation seeks to contribute to the understanding of how CE enablers facilitate the implementation of CE practices through a qualitative case study approach. Qualitative research is as important as ever: in a rapidly changing, globalizing world, the value critical qualitative inquiry brings to academia is pertinent (Denzin & Lincoln, 2018). This dissertation embraces a phenomenological qualitative research methodology, inspired by critical theory and constructivist paradigms of inquiry. The dissertation therefore presents an interpretation of a moment in time where CE appears to have a significant impact upon the global business agenda. First the results are presented, followed by the contributions of the dissertation to theory and practice, and lastly the limitations of the study and future avenues of research are presented.

In the quest to contribute perspectives on how CE enablers facilitate the implementation of CE practices, this dissertation identifies 14 CE enablers and explores how they facilitate the implementation of CE practices. The 14 enablers are 1) competencies availability, 2) customer availability, 3) connector availability, 4) collaboration, 5) coordination, 6) culture, 7) a center, 8) political, 9) regulatory, 10) sociocultural, 11) technological, 12) AI based analytics, 13) mobile apps, and 14) algorithms. Answering the overarching RQ "how do CE enablers facilitate the implementation of CE practices?" this dissertation shares two perspectives: 1) CE enablers change the status quo, thus prompting action from individual business, and 2) DTs and technological advancements accelerate the implementation of CE practices. These CE enablers are found to support and engage entrepreneurs, shape, enhance and trigger venture creation, change business and material practices, and assist with customizable data collection, analysis and interpretation. CE is experienced as a phenomenon with increasing presence for many businesses, and perhaps the pathway to become more circular is a journey on a spectrum, rather than a clear-cut end state. The pathway is empowered through both external and internal CE enablers, in which the common denominator is that they must be acted upon to bring value.

Theoretical contributions to research provide original insights and advance knowledge (Corley & Gioia, 2004). The main theoretical contributions of this dissertation concern the CE enabler literature. Despite this dissertation being of a qualitative case study nature and the findings thus not easily generalizable, the contextual conditions can be similar for other businesses across the same or different industries, and thus the findings may be considered transferable (Gioia et al., 2013). This thesis contributes original insights to the literature on CE enablers by explicitly tying macro-level CE enablers with micro-CE enablers. The novel contributions to the literature on CE enablers include the two key findings discussed in section 5.1. The two key theoretical contributions provide the understanding that CE enablers create a market disequilibrium which demands a response from individual businesses, and that DTs and technological advancement appear to act as

accelerators of CE implementation. The individual publications included in this publication also contribute novel insights to literature as detailed in chapter 4 where the results of each publication is summarized.

The findings in this dissertation are also interesting from a practical perspective, as they provide both tools and insights for managers, policy makers and startups as well as entrepreneurial ecosystems. Practitioners should pay attention to the findings highlighting how CE enablers at the macro level unlock micro-level CE enablers. Changes to the market equilibrium should be thought of as unlocked opportunities rather than a disadvantage – yet this is a luxury for businesses with certain skills and values. These skills and values often coincide with micro-level CE enablers and can therefore be pursued in a structured manner. It should also be interesting for practitioners to learn just how big a difference DTs and technological advancements make in the implementation of CE practices. Investing in tech upgrades may pay itself back and more, but it may also create benefits further down the road, because technology keeps advancing and becoming more and more integrated in product-related and production-based processes and solutions. Technological developments may be even more beneficial to businesses if they partake in the development of technology that would specifically improve their own area of business.

The data collected, analyzed and presented in this dissertation is of a qualitative nature and consequently derived from a limited number of data sources. All data is collected from businesses that are either self-proclaimed frontrunners or self-starters focused on CE solutions. For this reason, the level of CE understanding is presumably higher than the average business or startup. By design, this limitation creates a focused scope. This arguably high level of CE perception may have a positive impact on the views the business have and present on CE. Future research could conduct similar studies with CE frontrunners in other industries or countries and compare the findings to the ones in this study.

The cases and contexts are described and presented in detail for researchers and practioners to assess the possibility of transferable findings. The findings summarize and present perspectives as perceived by businesses responding to CE enablers. The data is collected from businesses already implementing CE practices and based in a country with a high level of awareness of CE both at the authoritative and socio-cultural level, thus providing valuable insights on how macro-level CE enablers may be leveraged even further to push the implementation of CE practices. Future research could conduct similar studies but with businesses not pursuing CE at the moment, in order to better understand how CE enablers could facilitate the implementation of CE practices under such conditions.

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Publication I

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THE CIRCULAR WATER ECONOMY AND THE 'SEVEN C's'

<a>ABSTRACT

Scholars in the field of sustainable entrepreneurship have highlighted the need for future research to examine how a supportive external environment for sustainable entrepreneurship can be created (Bischoff and Volkmann, 2018). In order to address this research gap, we conducted a study on a regional circular economy ecosystem centered in the recycling of wastewater. The study is based on 45 user-stakeholder interviews from 10 different types of organizations within a local sustainable entrepreneurship ecosystem, based in Finland. The findings highlight the importance of conscious, collaborative stakeholder support and ecosystem coordination for creating strong sustainable entrepreneurial ecosystems. This chapter then offers a contribution to fill the research gap in terms of a framework for a supportive environment for entrepreneurs within sustainable entrepreneurial ecosystems, founded on seven enablers crucial for entrepreneurs to pursue circular endeavours.

<a>KEYWORDS:

Circular Economy; Sustainable Entrepreneurial Ecosystems; Innovation and Entrepreneurship.

<a>INTRODUCTION

In the introduction to this book, the editors emphasise that there is a lack of knowledge about the institutional and societal transformations needed to implement circular practices, particularly those requiring radical changes at societal and institutional level, and therefore there is an urgent need for a more comprehensive understanding of how such circular economy (CE) innovations can be achieved. This chapter tries to add some understanding of system or ecosystem level enablers for circular economy innovation focused on the perspectives and experiences of entrepreneurs trying themselves to enter the circular economy with innovative products and services. It is based on the study of an eco-industrial park, called 'EcoSairila', in the Finnish city of Mikkeli. Mikkeli is located c. 230 kms north east from the capital Helsinki, in the Saimaa lake area and has a population of c. 55,000 people.

EcoSairila is boosting the regional, circular water economy, around the recycling of wastewater, based on the logic of industrial symbiosis and related innovative, new businesses. We studied this case to better understand what conditions within the local, sustainability-focused, entrepreneurial ecosystem would energise entrepreneurs to enter the CE. Although large cities have been studied, to our knowledge no research exists addressing the transition to a CE in small and medium sized towns and cities such as Mikkeli. EcoSairila is a cornerstone of Mikkeli's smart specialization strategy. By 2030 the goal is to generate new, Mikkeli based, symbiotic start-ups and SMEs with a collective turnover of over €100m.

EcoSairila's goal is challenging on many levels. Any business opportunity identification, in particular novel CE opportunities, is difficult (Bechtel et al., 2013; Rizos et al., 2016). Several authors note that there is often a general lack of technologies, knowledge and technical skills for more 'advanced technical´ options (Rizos et al., 2016). CE businesses also typically involve

multiple stakeholders and a need for suitable partners (Bechtel et al., 2013), and hence, challenges in collaboration within some form of an ecosystem are further accentuated. Prior research has highlighted that some form of external support from the entrepreneurial ecosystem is crucial to entrepreneurial success, in particular for sustainable entrepreneurship (Cohen, 2006). However, a grand challenge for sustainable entrepreneurial ecosystem stakeholders is that the nature of the interactions within an ecosystem and the conditions for creating a supportive entrepreneurial ecosystem remain unclear (Cohen, 2006). Similarly, the perspective of the entrepreneurs themselves is rarely considered when designing and improving such support systems (Hakala et al., 2019; O'Shea et al., 2019).

In order to support EcoSairila to attract and grow innovative CE start-ups and SMEs, we posed the following research question as central to our case study: *"What enablers need to exist within the local sustainability focused entrepreneurial ecosystem to engage and support innovative CE focused entrepreneurs?"* While we conducted a case study of EcoSairila with specific practical aims, we also contribute to the literature on sustainable entrepreneurial ecosystem development by developing a framework for ecosystem enablers that encourages entrepreneurs to focus their efforts on innovating for a local circular water economy. The seven identified enablers are: *competences*, *customers*, *connectors*, *collaboration*, *co-ordination*, *culture* and *centre*, which we term collectively "the Seven C`s".

<a>ENABLERS FOR CIRCULAR ECONOMY ENTREPRENEURSHIP

To identify the relevant enablers and to construct an initial conceptual framework for our study we scouted the existing literature for enablers in CE focused ecosystems (Bechtel et al., 2013; Rizos et al., 2016) and regional CE development referring mainly to studies focusing on local

eco-industrial parks (Mathews & Tan, 2011; Ghisellini et al., 2016). Added to these, we also perceived other related topics such as sustainable entrepreneurial ecosystems and generic entrepreneurial ecosystems literature (Cohen, 2006; Mason & Brown, 2014). Related to CE, prior studies have focused mainly on Chinese regions and towns, but some studies also consider European countries like the UK, the Netherlands, Denmark, and Germany (Ghisellini et al., 2016).

From these studies, we searched especially for *key components and actors* within these systems (Cohen, 2006; Mason & Brown, 2014) which then allowed us also to decode the core enabling components. First, a clear enabling component relate to *competences* that the entrepreneurs have themselves. In particular, access to various 'sustainability competences' (Eizaguirre et al., 2019), technologies, knowledge, information and technical skills, that help the entrepreneurs to identify, assess and implement 'advanced technical´ options for their business (Rizos et al., 2016; Bechtel et al., 2013).

In previous studies, another important enabling component is the presence of customers who offer piloting opportunities for new products and create market demand for sustainable business ideas (Rizos et al., 2016). Business to business customers inside the system can provide extremely valuable symbiotic relationships (Chertow, 2007).

Within ecosystems, the importance of a *connector* role is also highlighted (Shane & Cable, 2002). For instance, the use of experienced business people (Mason & Brown, 2014), researchers acting as diplomats, missionaries and knowledge brokers (Haarla et al., 2018), and organisations acting as agents or brokers in the innovation process (Kanda et al., 2018). Another key enabler is *collaboration*, which increases productivity, reduces R&D costs and creates shared sense-making (O´Shea et al., 2019) around new opportunities. Collaboration also enables the finding and developing of suitable partnerships (Bethel et al., 2013),

understanding and contacting markets and customers efficiently (Rizos et al., 2016), and distributing new ideas in the ecosystem (DiVito and Ingen-Housz, 2019).

Coordination within the ecosystem leads to increasing efficiency, coherence of activities and prevention of overlapping functions and roles (Jacobides et al., 2018). This can mean for instance coordinated decisions and integration of sustainability product concepts into businesses (O'Shea et al., 2019). Coordination is also about clarity, e.g. around ecosystem identity, its shared goals, policies and governance (Hakala et al., 2019). Previous studies use the term "entrepreneurial climate" or "entrepreneurial *culture*" as important part of entrepreneurial ecosystems (Malecki, 2018). But besides being entrepreneurial, the *culture c*an also embrace the idea of the CE as a whole (Mathews & Tan, 2011) and allow shared sustainability orientation amongst the stakeholders (O´Shea et al., 2019; DiVito and Ingen-Housz, 2019). Finally, according to previous studies the idea of a *centre*, a physical and virtual place, is important as a visible symbol for the existence of the ecosystem. The real value of the centre is created by its function that unites various supporting resources, partly enhances the supportive culture and makes related services more accessible for entrepreneurs (Spigel, 2016).

<a>METHODOLOGY AND CASE DESCRIPTION

The Mikkeli Blue Economy Water Hub, also known as 'EcoSairila', is a CE business park which functions as a center of excellence in water circularity research, processes, and business. The €100m investment includes local communications and transport structures as well as funding for 'blue economy'[1] research and development by local universities. A Membrane

[1] By this concept we refer to better stewardship of our natural water resources. Like in the concept of "green economy", the blue economy model aims for improvement of human wellbeing by promoting circular economy and significantly reducing environmental risks (modified from: https://thecommonwealth.org/blue-economy)

Bioreactor (MBR), wastewater treatment plant and water reclamation plant has been built 40 meters deep in the bedrock adjoining Mikkeli city and Lake Saimaa and the park incorporates research and pilot facilities, and a biorefinery producing biogas and organic nutrients. EcoSairila is in a privileged position in that it is closely connected with water separation scientists at two local universities and other water treatment partners on site. There are also other excellent support resources within the ecosystem including a regional development agency, the resources of the city itself and of the regional (county) council acting as coordinator for EU-funding.

For the purposes of the study we undertook 45 user-stakeholder interviews, conducted between spring 2019 and summer 2020. The respondents were 28 individuals from 10 different organizations within the EcoSairila ecosystem including SMEs, pre-start-ups, development agencies, research labs, civil servants and EcoSairila itself. The interviews lasted between 45 and 60 minutes. The transcripts and meeting notes comprised c.350 pages of data.

The overall goal was to develop a framework for various stakeholders such as regional development organization and the local members of a research and education cluster when building an entrepreneurship focused CE. Finally, to understand practical implications of our framework, we tested its logic on a start-up within EcoSairila. This start-up is a brewery company that wants to be amongst the world's first to use waste (sewage) water to brew its beer. This short example is also included at the end of the chapter to show how the final model can be applied to a case.

<a>FINDINGS AND ANALYSIS

Our analysis is data-driven and theory based around these clusters, developing the model through theory-practice iterations, conceptualized eventually as the Seven C's**:** *Competences, Customers, Connectors, Collaboration, Coordination, Culture and Center.*

<b>Competences

Our data highlights that CE – related competences were acquired elsewhere than in the Mikkeli region, or if in the region, in some other working life context than as an entrepreneur. In several examples, the entrepreneur had moved to the area because of a close connection to the region or other contacts already in the area. Most often the entrepreneurs had built their "sustainability orientation" (O'Shea et al., 2019) in the Helsinki region where access to various "sustainability competences" (Eizaguirre et al., 2019) had opened. For example:

"I guess I have held quite long these green values and thought about my idea...but it helped me that the Mikkeli area is a good area to live a healthy life near the nature…"

Some entrepreneurs had personal ties, such as family, friends and other informal networks, which they favoured as a partner competence over the ability to set up a business (D´Hont et al., 2016). Sometimes this access to crucial competences had been found amongst trusted friends with shared values and "sustainability orientations" (O'Shea et al., 2019). In terms of formal organizational competences used for entrepreneurial concept support, the city development agency was mentioned several times:

"The biggest thing was that there was only one person …. [I could get help and advice for] everything …starting the business and getting funding, or legal advice or anything like that via one contact person"

For water circularity expertise, Mikkeli has two university research groups of ‘water separation’ scientists that is relatively large and highly qualified in its area globally. There is also further technology and process expertise within the EcoSairila park itself. Mentors, university alumni and other experienced actors with social capital also act as an enabler. However, the access to network competences is something in which respondents would like to see improvements; they felt that the system needs more and different experts to be readily accessible. Recent new ventures have relied on venture coaches and innovation agents being sourced from a green innovation centre in a different town. While this has been helpful it was felt that this dependence on experts from a neighbouring region was not an optimal solution:

“One of our challenges in Mikkeli, if we want to do something similar like in many places already, is to have someone who helps researchers and businesses to collaborate, the so called, (green) innovation expert”

<b>Customers

This enabler refers to the demand for products and services both inside and outside the ecosystem. The EcoSairila ecosystem is fortunate in that there is a company that manages the whole water treatment cycle, which provides a market outlet and other customer possibilities for other entrepreneurs in the field. Respondents felt that EcoSairila could offer a good context where new sustainable business ideas could emerge also in B-to-B – business (Pastakia, 1998) in the symbiotic relationships:

“...LP company, which is the biggest barley producer in Finland, they have an interest to build this full circle so that the end-waste from EcoSairila biogas-plant would go to the fields of the barley farmers [as fertilizers]. So, it would make the full circle.”

For customers outside of the ecosystem, several respondents were positive that nationally there is and will be "green customer potential" (Gleim et al., 2013) increasing in the future:

"I guess in that respect we are relatively lucky in Finland that we have some systems [for recycling / circularity] already... and people don't naturally just throw trash on the floor, and these kind of things..."

<b>Connector

The enabler importance was highly visible in the interviews. It was used for example to describe persons working in MIKSEI, Mikkeli city council or the Mikkeli University Consortium (MUC):

"Mr M also sees the Mikkeli University Consortium as a part of the discussions around regional development, helping to build coherence strategy within the ecosystems, that different organisations have different roles, so one important thing it does is host meetings, gathering people to meet."

It was also used to refer to the need for a facilitator (Gliedt et al., 2018; Howells, 2006; Kanda et al., 2018; Kivimaa et al., 2019) to work in the system as 'innovation intermediaries' or specialists (Patala et al., 2020) facilitating innovation processes and creating new opportunities.

<b>Collaboration

The need for Collaboration, like the 'Connector' enabler, is something that most respondents were very aware of. Collaboration can enable the finding and developing of suitable partnerships (Wooi and Zailani, 2010), contacting markets and customers efficiently (Rizos et

al., 2016) and distributing ideas efficiently among different actors in the ecosystem (DiVito and Ingen-Housz, 2019):

"MIKSEI, has had discussions with all the universities... they have constant discussions with the local businesses, they do that work."

At a strategic level, six or seven core stakeholders meet regularly, but still there is a feeling that more enabling, dense collaboration could take place:

"We have been discussing that we should have more meetings…We are trying to get closer."

At an operational level, respondents would like stakeholder collaboration to also focus on researchers and graduate students, to bridge the gap between sustainable entrepreneurship ideas and turning those ideas into start-ups:

"We have had some meetings trying to find some businesses from students, and…we (currently) lack...straight line from the student idea to the business, and the support."

One issue appears to be that the overriding shared sustainability intent (O'Shea et al., 2019) is not yet powerful enough and that ecosystem collaborators are not having "the sense of urgency" to support a systemic regional approach in CE business development, versus a pre-occupation with their individual roles:

"Maybe we all have too much to do in our own work and do not have time for this type of exercises."

While Mikkeli city has enabled many things to support local CE entrepreneurship, still, respondents mentioned that more openness is needed; if collaboration is weak, or non-systematic, then trust among different parties will not grow to the level needed.

<b>Coordination

This enabler has not naturally emerged in the Mikkeli CE. The city council recognizes this and the director for development explains the city's role as facilitating openness and more coordination within the ecosystem. However, CE entrepreneurs within the system would like to see this done more formally:

"Seems that no one is controlling the system level…"

Some respondents would like the regional organizations to be more focused and coordinated:

"the spill-over effect that would come from, for example the research done by the university water research groups…maybe there could be some kind of coordination in the means of research done by these organisations."

At the same time, several users would also like to see more clarity (in how the system fits together and how it works for their interest) and more formal coordination:

"I know that MIKSEI is there and some other players, but it is very hard to get the overview. Who does what and how do different parts fit together…right now I think they do not necessarily fit together?"

<b>Culture

Components of the Culture enabler are still relatively underdeveloped. EcoSairila is taking its first steps in development and attempts to build a CE brand to persuade entrepreneurs to establish their businesses locally. Many interviewees saw that regional "entrepreneurial culture" has been advancing through the presence of the MIKSEI development agency and EcoSairila. However, more needs to be done to develop this entrepreneurial culture and this specific cluster where a new business could fit as:

"it requires rather than an individual or even small company thinking, it requires cluster thinking to be able to, to take [-] and there for the circle and the circle economy, just to repeat, doesn't take place at the individual or even small groups, small business."

<b>Centre

Many of the respondents considered that the Centre, the actual place of activity was an important enabler for the ecosystem, particularly in terms of the CE. The investment on the CE park site has been significant at €100m and the resulting infrastructure and water purification facilities provide piloting and prototyping possibilities as a foundation for technology start-ups:

"Plants need to start first…we need the big stuff first so to speak…then the SMEs will come…"

However, SME respondents stated that there does not exist a single centre in the traditional physical building sense. Even if respondents had identified some shared events between different stakeholders in the ecosystem, the importance of the physical centre was brought up in some interviews:

"Even though it was very helpful to achieve concrete and very valuable help by MIKSEI and having one person to talk to all the time…in overall I guess it would be helpful to have one physical recognized place for start-ups in the area"

We summarise our findings and analyses, in Table 1 below, which provides an overview of the **Seven C's** model or framework as the main contribution from this chapter.

<a>**CONCEPTUAL FRAMEWORK**

The proposed framework on sustainable entrepreneurial ecosystems and its propositions provide practical insights for sustainable entrepreneurs concerning their interactions with stakeholders of sustainable entrepreneurial ecosystems. Strong stakeholder relationships, multi-stakeholder partnerships and extensive support can in turn facilitate the operations of a sustainable small enterprise.

Table 1 : CE enablers from the entrepreneur's perspective

CE enablers	**Relevant literature on enablers**	**Key findings in the case study**
Competence availability: (1) of entrepreneur(s) themselves; (2) through the system.	Especially various 'sustainability competences' (Eizaguirre et al., 2019), technologies, knowledge, information and technical skills, enabling 'advanced technical´ options for their business (Rizos et al., 2016; Bechtel et al., 2013).	(1) Often acquired outside the region; sustainability linked to pre-existing values; informal networking; region attractive for living. (2) Key development agency support; but lack of innovation expertise
Customer availability:	Industrial symbiosis (Chertow, 2007) and especially focusing on green values and practices of consumers (Gleim et al., 2013).	Already B-B – green business especially fitting EcoSairila and overall supposed B-C green customer potential.
Connector availability:	Conversants (Shane and Cable, 2002) experienced business people (Mason and Brown, 2014), researchers (Haarla et al. 2018), third-party, broker, and facilitator (Gliedt et al., 2018; Howells, 2006; Kanda et al., 2018; Kivimaa et al., 2019).	Some connector support already existing, such as a development agency, city council, university consortium.
Collaboration inside the ecosystem:	Increases productivity and reduces costs (Acs et al., 2008); collaborative sense-making (O´Shea et al., 2019); partnerships (Wooi and Zailani, 2010), contacts to customers (Rizos et al., 2016) and distributing ideas in the ecosystem (DiVito and Ingen-Housz, 2019).	Identified as something which is needed more, but it has the classical problem of investment need without the certainty of useful outcomes, trust needs to develop. Support is available as connectors host meetings, gathering people, organize networking hubs.
Coordination: system level fitting the parts of	Shared goals, and policies boundaries and governance (Hakala et al. 2019); efficiency and coherence (Jacobides et al. 2018); co-	Desire is to get an actor to take a more formal role to coordinate different parts of the ecosystem. The current system is

the ecosystem together.	sensemaking and co-integration (O'Shea et al., 2019).	informal and 'facilitated' by the city council through 'nudging' activities.
Culture: an innovation oriented and sustainability willing or demanding culture	Both entrepreneurial culture (Malecki, 2018) and culture promoting circular economy (Mathews & Tan, 2011) and shared sustainability orientation amongst the stakeholders (O´Shea et al., 2019; DiVito and Ingen-Housz, 2019).	There already exists a sustainability willing culture. EcoSairila developing the brand image as an EU centre of water excellence; It has persuaded some entrepreneurs to establish their businesses in the CE park.
Centre: a physical and virtual place	Unites various supporting resources, enhances the supportive culture and makes related services more accessible for entrepreneurs (Spigel, 2016).	EcoSairila is growing as a physical centre of excellence for water circularity and research, but a clear and visible centre is needed for creating access for specific resources

This model can be applied as a starting point for sustainable entrepreneurial ecosystem development, and then as a reflector of status along the developmental path of the ecosystem. Here, below (Table 2) we illustrate how the framework relates to a CE start-up brewery based in EcoSairila aiming to utilize the purified wastewater in their beer production.

Table 2: Illustrative example of the Seven C's model applied to the case of a local SME

Competence availability**:* Sustainability competences and related knowledge for water circulation are present in EcoSairila and in the university water circulation lab. From the founding partners, one came with some brewery experience and the other is a business school graduate. The brewery received key development agency support related to funding, piloting, and legitimizing in its early phase. ***Customer availability: The established 'Saimaa' brewery is based in Mikkeli and there is already a brand for mainstream Mikkeli beer. Organic microbreweries themselves have a local and national market. Finnish supermarkets and consumers provide a nationally available 'green customer potential'. ***Connector availability:*** The director of EcoSairila has himself been the main connector for the brewery and the CE ecosystem support functions, especially the development agency, Miksei. ***Coordination***: For the brewery, a high level of clarity of the ecosystem exists, as they are closely connected to EcoSairila and its director, physically and mentally. Coordinated ***Collaboration*** is enabled via the main connector person, the director of EcoSairila. ***Culture*****:** the brewery benefits from the water circularity brand of EcoSairila and aims to be the first all circular economy brewery in the world. There is also a subculture of craft beer enthusiasm in the area due to the other relatively successful craft brewery in the city, as well as due to national and international trends. EcoSairila is developing a CE brand image and has persuaded current and nascent entrepreneurs to establish their businesses in the CE park. It is also growing into an EU centre of excellence for water circularity and the city is known

for its CE technology and processes; University research units also hold open research conferences/research impact activities with EcoSairila

***Centre**:* The brewery is based in the CE park which houses the "centre" water treatment, biogas, and fertiliser plants. Business support available in city centre is only 3kms away. The business park functions as a physical centre of activity and the centre of service, knowledge and support is in the city centre.

The main theoretical contribution of this study is the above Seven C´s model. As far as we know, this model is the first attempt to unite, into a theoretical and practical model, different enablers identified both in generic and sustainable entrepreneurship ecosystem research and the literature around CE focused ecosystems and regional CE development (the local eco-industrial parks). Even if not exhaustive, we consider this model as a good starting point when beginning to theorize sustainable ecosystem enablers around large eco-developments like EcoSairila. For strengthening this entrepreneur-centered and in-depth view we would highlight the importance of analyzing user experiences of future entrepreneurs with various service design techniques (for instance Helkkula et al. 2012), focused on these ecosystem enablers.

<a>CONCLUSIONS

This case study was about EcoSairila, in the city of Mikkeli, Finland. This chapter puts forward a framework or model of enablers which support entrepreneurial engagement in the circular economy. This model is founded on the process view of ecosystems, placing the entrepreneur as a key user of the process. In our view it is important to build an in-depth understanding of enablers, within an ecosystem, for entrepreneurs to be confident enough to take CE opportunities.

This model can be of value to existing and aspiring sustainable entrepreneurs, those working as intermediaries, and stakeholder support organisations, in the following ways:

- For regional sustainable innovation and CE policy makers to gain a better overview of the existing collaboration and support mechanisms for sustainable entrepreneurship
- by using this model as a benchmark to identify specific areas of an ecosystem which are in need of further development or which require additional stakeholder support for sustainable entrepreneurship
- For ‘connectors’ and intermediaries to use as diagnosis model to see where their contributions are needed (Kanda et al. 2018)
- an audit tool for individual stakeholder organisations, to review how they participate and collaborate and support local CE entrepreneurship
- This model could be utilized in practice as a tool for CE ecosystem development facilitation (Kanda et. al 2018), for example in stakeholder workshops

Overall, our findings will encourage the establishment of extended collaboration and support mechanisms for entrepreneurs with a specific focus on sustainability, such as sustainable investments, sustainability education or sustainability-focused governmental incentives. Enhanced stakeholder support can ultimately influence larger institutional structures and norms leading to institutional change towards sustainability. Through increased engagement in sustainable entrepreneurship, stronger sustainable entrepreneurial ecosystems could further pave the road towards a more sustainable future.

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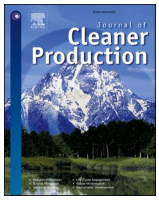

External enablers for the circular economy: A case study of the food packaging industry

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ABSTRACT

The paper explores how the food packaging industry leverages external enablers in a transition to a circular economy (CE) and is a first to bring together the literature on external enablers of entrepreneurship with CE. Utilizing qualitative data, the findings offer insights on how CE related external enablers for the food packaging industry transformation. The paper adds empirical credence to the conceptual claims of the external enablement framework. The findings suggest that packaging manufacturers react to four enablers linked with CE, that push them toward circularity: political, regulatory, socio-cultural and technological. The industry is moving convergently and leveraging a relatively small range of mechanisms that shape the existing business. In addition, while we find that regulation is perhaps the most important enabler shaping the business, the triggering of more advanced innovation or entirely new ventures requires additional enablers.

1. Introduction

The food packaging industry is under pressure to adapt more sustainable practices in which circular economy (CE) plays an instrumental role. The CE concept has become central for many governments aiming to support environmentally sustainable economic development (Hartley, van Santen and Kirchherr, 2020). The food packaging industry is a particularly intriguing CE context due to health and safety aspects related to food, high complexity, and high reliance on single use packaging usage. The food packaging industry is affected by CE which is a sociocultural megatrend with interrelated regulatory, technological, political, and sociocultural elements acting as external enablers (EE) of change (Kimjeon and Davidsson, 2022). The EE-framework applied in this study aims to understand how entrepreneurial opportunities arise and new venture formation occurs (Davidsson, 2015; Reuber et al., 2018) in the food packaging industry partly because of EEs. The EEs are aggregate-level circumstances that create a disequilibrium in the business environment (Davidsson et al., 2020). Disequilibrium in the market presents both opportunities and threats to entrepreneurial activity, yet nonetheless suggests a change to the business-as-usual situation is warranted (Bocken, 2014). Consequently, EEs will not favor all actors or new ventures equally (Davidsson, 2015), and entrepreneurially driven innovation is vital to convert external conditions to spur successful business (Shane and Venkataraman, 2000).

This study builds on the idea that CE creates strong EEs to build new ventures or reshape existing ones. Prior empirical studies on EEs remain rare in any context, and we are unaware of any study on EEs in the context of CE. Prior work has typically focused on studying the effects of a single enabler at a time, yet the food packaging industry is affected by multiple EEs interacting simultaneously. Therefore, we respond to Davidsson's (2019) call to empirically study the effects of multiple EEs occurring simultaneously. We do so by examining the food packaging industry which has been in the public spotlight owing to the high volumes of waste produced. The attention has created pressure from consumers, retailers, and governments to develop more environmentally friendly business practices. Hence, we propose that multiple EEs currently favor new ventures in the food packaging industry that incorporate circularity into their business models. We apply the EE-framework to incumbent firms and start-ups alike, perceive their product innovations as new ventures, and ask, "How is the food packaging industry leveraging EEs during the transition to a CE?"

Responding to the call for understanding the external pressures for CE (Gusmerotti et al., 2019), our findings suggest that two or more mechanisms can interact and thus elicit both an individual firm response and an industry response. The findings suggest that companies within the same industry often move rather convergently when pursuing CE, yet certain EE mechanisms provoke novel packaging innovations and trigger new ventures. By capturing the interplay of multiple EEs and

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mechanisms in the food packaging industry, the compounded role also adds a layer to the analysis and novelty of the research. By revealing how the different enablers act and what kind of outcomes they produce in the food packaging context, the findings also provide interesting insights for policymakers. For example, policies pushing the recyclability and recycling of packaging materials have generated an industry response that favors simpler mono-material packaging. For practitioners, the findings highlight that while CE-related EEs create an impetus for change, they can also provide opportunities for new business development and outcome enhancement and help to shape more future-proof business models.

2. Theoretical background

2.1. The CE concept

Research on CE should focus on how upstream production and consumption might be changed (Merli et al., 2018). This paper defines CE as "an economic system that replaces the 'end-of-life' concept with reducing, alternatively re-using, recycling and recovering materials in production/distribution and consumption processes" (Kirchherr et al., 2017, p. 229). Although this, like many others, does not specifically incorporate competitiveness and profitability aspects (De Angelis, 2020), economic sustainability is critical to successful CE entrepreneurship (Ranta et al., 2018). Research has criticized circular business models for not addressing psychological, social, and cultural needs (Singh and Giacosa, 2019). Many firms are hesitant to switch to environmentally friendly materials (Schillebeeckx et al., 2022) and are often averse to moving beyond a recycling-based CE approach (Ranta et al., 2018) particularly if they require more resources (Whalen, 2019). CE is complex and typically includes many stakeholders who are dependent on each other for the successful implementation of the circularity (Mishra et al., 2019). There is thus a sharp contrast to the situation in the prevailing linear economy where each company along the supply chain optimizes its own operations, sometimes to the detriment of other companies in the supply chain. Several studies have focused on the drivers and barriers affecting CE (Caldera et al., 2019; Vermunt et al., 2019). Some research indicates the main drivers of an intention to implement CE are energy savings, environmental protection, financial incentives, and tax reductions; however, consumer demand (Kumar, Sezersan, Garza-Reyes, Gonzalez, & AL-Shboul, 2019) and regulatory pressure (Gusmerotti et al., 2019) appear less prominently. Other studies found profitability, market share, cost reduction and environmental concerns were the key drivers (Agyemang et al., 2019). Nevertheless, economic drivers were the most influential motivators for linear companies to adopt circular business models (Gusmerotti et al., 2019). While going circular is closely connected with companies' environmental responsiveness, there are likely legislative and other stakeholder pressures beyond economics pushing companies toward CE (Bansal and Roth, 2000). Such stakeholder pressures vary across continents (Ranta et al., 2018) but might necessitate firms acquiring a social license to operate in the future (Demuijnck and Fasterling, 2016). Core stakeholders exerting pressures include end-consumers, food manufacturing-customers, retailers, recycling-firms, authorities, competitors as well as suppliers. Hence, CE related EEs provide business opportunities for many companies in different industry sectors and parts of the supply chain (Esposito and Soufani, 2018).

For the food packaging industry in particular, the bottle-to-bottle recycling of PET has been highlighted as the perfect example of a closed loop CE. A relatively small number of countries have implemented a direct deposit scheme (DRS) system (Gupt and Sahay, 2019) in which PET bottles are collected separately. Additionally, some countries have an informal PET collection system (Welle, 2011) which brings PET to mechanical recycling facilities, and then sold as rPET pellets and used in the production of new beverage bottles with varying percentages of rPET content. rPET however is not an appropriate material for all food packaging due to a variety of factors including brittleness and heat resistance among others, therefore novel ways of engaging the food packaging industry in CE, even an open looped CE is necessary to include the many non-PET food packaging materials.

2.2. The external enablement framework

Irrespective of how much motivation or expertise entrepreneurs possess, entrepreneurship cannot occur without an accompanying opportunity (Short et al., 2010). Opportunities, whether discovered or created, relate to the external conditions of the entrepreneurs, and external conditions can be as important as the entrepreneurial agent itself (Shane and Venkataraman, 2000). In this study, we adopt the EE-framework developed by Davidsson et al. (2020) to analyze entrepreneurial responses to external change. While the framework recognizes the important role of the entrepreneurial agent, it focuses on the factors of the context in which the agent acts. The EE-framework specifies the following distinct types of EEs 1) technological, 2) regulatory, 3) demographic, 4) sociocultural, 5) macroeconomic, 6) political, and 7) natural environment (Davidsson et al., 2018), these types explain where an EE originates from. The form and structure of each type of EE can be delimited in terms of its characteristics, scope, and onset (Davidsson et al., 2018). In the model, mechanisms specify the relationship between a specific type of EE and the benefits derived from it. Mechanisms are relational and describe the function of the EE; thus, the benefits derived from EEs are specified through the mechanisms category in the framework (Davidsson et al., 2020). The EE-framework identifies 11 distinct mechanisms; 1) compression, 2) conservation, 3) resource expansion, 4) resource substitution, 5) combination, 6) generation, 7) uncertainty reduction, 8) legitimation, 9) demand expansion, 10) demand substitution, and 11) enclosing. (Davidsson et al., 2018). However, which mechanisms are deployed depends on the characteristics of the enabler and the venture itself, and mechanisms can interact to create secondary functions. (Davidsson et al., 2020). Finally, an EE can also be described in terms of its role in the venture creation, depending on which stage of the venture creation process the EE influences. Like mechanisms, roles are also relational and may play the following roles; 1) shape 2) enhance or 3) trigger entirely new ventures (Davidsson et al., 2018). The shaping roles of EEs are manifold ranging from shaping a specific product to shaping the product offerings and, eventually, the entire venture. The outcome-enhancing role was explained in terms of achieving an equivalent output with less input or greater output from the same input. The triggering role is exemplified through the novel innovations offering companies opportunities to enter new markets.

2.3. The CE as an EE

Similar to digital transformation, for example (von Briel et al., 2018), the adoption of CE thinking has caused multiple changes to the business environment. While these changes are a source of uncertainty, they offer many business opportunities (McMullen and Shepherd, 2006). Therefore, by causing disequilibrium in the market, CE can be seen as an EE with multiple origins based on the associated changes in regulations, consumer preferences, political discourse, and technology. These effects and scope also vary along spatial, sectoral, socio-demographic, and temporal dimensions of the environment (Davidsson et al., 2021). Spatially, CE is a widespread idea, and changes pushing the CE agenda include stricter regulations on a national and global level. While European countries are perhaps leading the charge toward circularity, with most member states having developed policy roadmaps to facilitate it (Smol, 2021), the CE concept has also spread widely outside the EU (e.g., Zhijun and Nailing, 2007). As with any other EEs, CE related EEs affects many sectors of the economy but is not necessarily beneficial for all of them, and also restricts some types of business opportunities. For example, the producers of single-use packaging or any natural resource-intensive sector that cannot utilize recycled materials are likely

to feel a strong pressure to change as consumer values shift to favor value sustainability. Hence this sociocultural shift creates both a moral, and a more rational, business-driven impetus for companies to advance the CE (Bansal and Roth, 2000; Schillebeeckx et al., 2022). However, EEs catalyzing broad-scope changes create a wealth of opportunities for many new ventures (Davidsson et al., 2021). The CE movement has been gaining momentum since the 1970s (Geissdoerfer et al., 2017), and firms should theoretically have had time to change business models and processes and to develop entirely new ventures. The consumer intention to consume more responsibly is a global trend while the actual consumer behavior to pay more for eco-friendly and recyclable products is debated (Tawde et al., 2023) the desire for plastic-free or otherwise environmentally friendly packaging has been observed by the industry professionals (Angus and Wesbrook, 2019). Irrespective of whether consumers are actually willing to pay more for circularity, the perceived changes in consumer values have influenced legislative moves (e.g., the single-use plastics directive, producer responsibility legislation, and recycling targets set by the EU Packaging and Packaging Waste Directive). In addition, many large customer companies in the food industry (e.g., Nestlé, PepsiCo, Mars, The Coca-Cola Company, and Danone) have pledged to make their packaging fully recyclable (Phelan et al., 2022). All this is creating strong pull factors for the food packaging industry to provide more circular solutions to their immediate customers in the food industry.

3. Empirical setting and research method

The food packaging sector is one of the sectors much affected by CE. The sector is undergoing a transformation stemming from international regulations, technological advances, and new raw material markets, all of which originate from the CE acting as EE. The food packaging industry is also an interesting case owing to its high volume of single-use plastics and stringent food-handling hygiene standards. The packaging industry is also likely to continue its growth as the world population increases. To obtain a vivid picture of the food packaging industry through case study methods, we targeted both incumbents and start-ups, large public enterprises and smaller privately owned actors. To investigate CE related EEs in action, we purposively selected firms that actively pursue CE objectives. All eight main informant firms are headquartered in Finland but operate internationally and operate in the business-to-business markets as producers of food packaging. Both fiber-based and plastic-based packaging companies are included. The research team identified suitable informants by diligently canvassing industry experts, the Finnish packaging association, news outlets, LinkedIn, company websites, and participants at an annual industry exposition. The informants all held key leadership roles within the management teams of their companies and with sustainability responsibilities although their roles and titles vary due to the different organizational set-up in each company. Semi-structured interviews were conducted with each candidate and lasted between 25 and 60 min with an average length of 50 min. The eight semi-structured interviews allowed additional topics to arise (Pietkiewicz and Smith, 2014) and facilitated asking the interviewees follow-up questions. Each interview was conducted online owing to restrictions imposed in response to the COVID-19 pandemic and was recorded to enable detailed transcription and analysis utilizing NVivo 12.

This qualitative paper follows the descriptive framework analysis method for content analysis. The descriptive framework analysis method is used for research aiming to generate themes, has no allegiance to inductive or deductive research and has an established procedure for analysis (Gale et al., 2013). The semi-structured interviews were transcribed followed by in-depth familiarization with the content. The coding of the transcript contents then occurred before we developed an analytical framework through which we then interpreted the data in based on the EE framework by (Davidsson et al., 2020). The framework method is appropriate for the thematic analysis of textual data, particularly interview transcripts. As also applied in our study, it is important to compare and contrast data by theme across cases while also situating each perspective in context by retaining the connection to other aspects of each individual's account (Gale et al., 2013). The procedure benefits a case study in fostering an understanding of the big picture and rich and refined contextual interpretation (Eriksson and Kovalainen, 2016); precisely what is required to understand the transition to CE.

4. Findings

Four different types of EEs, political, regulatory, sociocultural and technological, were identified from the data. The **Political** enablers focused on the ethos of voluntary sustainability. Issues such as United Nations sustainability goals, *Roadmaps for the Circular Economy* and *The Plastics Roadmap for Finland* were mentioned as factors affecting the development. Perhaps surprisingly, political enablers enabling collaboration along the supply chain also seemed important, for example; (C3) "*A lot of the competition laws were relaxed in the EU during the pandemic, which allowed competitors to work together to get [circular] products to the market faster.*" The **Regulatory** enablers represent current legislation driving changes to establish CE, as exemplified by C9 "*The single-use plastics directive is very confusing at the moment, so it is not just creating good opportunities for innovation, but also chaos in the market space.*" Other regulatory issues mentioned included issues such as recycling targets set by the *EU Green Deal*, the *Plastic Packaging Tax* introduced in the UK, and differences in legislation across different countries. The **Sociocultural** enablers were centered around two intertwined topics; the customer (business-to-business) and consumer demand. The demand from the immediate customers of the packaging industry (food producers) appears to originate from consumers; "*All our customers, it starts from the biggest customers, they are asking for more environmentally friendly packaging, because they want to have some advantage toward the end-consumer*" (C7). But as some interviewees note, the sociocultural change in climate is broader and extends to other stakeholders too; "*A number of individual investors, who are socially responsible investors, have brought this up, but then a lot of the analysts and rating services, platforms that investors use, have circular economy linked questions that they want our company to respond to.*" *(C3)* This suggests that for firms operating in the business-to-business market, the consumer demand for sustainability has traveled upwards along the supply chain and becomes visible through the customer demand by food producers and retailers. In addition, **Technological** enablers in materials technology are driving the change and allowing solutions that, for example, reduce the amount of material used. "*We also have an invisible bar code … It is embedded into the print so you can cover the whole package with the invisible bar code … and has been remarked to be the best recycling technology*" (C2). However, technological development is also fueled by broader sociocultural change. As one interviewee said, "*First, there was the market pull, and then we had to find the technology.*" *(C4)*. Overall, there are many technologies, both incremental and more radical, being developed in the industry. Nevertheless, production cost, raw material availability, and supply issues (e.g., for recycled plastics) have often delayed market introductions. Table 1 illustrates further examples of enablers of CE see Table 2 for examples of mechanisms.

The data revealed five different mechanisms through which EEs affect businesses. These are combination, generation, conservation, resource substitution, and resource expansion.

The **combination** mechanism appears to have a strong strategic aspect and is associated with words like teaming up, partnering, discussing, co-creating and co-developing. These terms describe how this mechanism brings in partners from outside the company to provide new functionality. For example (C2), "*We are exploring whether we can team up with someone who can make shoes from recycled plastic.*" Leveraging the combination mechanism suggests well-developed relationships along the value chain may be more valuable in the transition to a CE because

Table 1
Exemplary quotes from sustainability managers identifying types of EEs driving CE in the food packaging industry.

External enabler type	Exemplary quotes from interviews with managers at each of the eight case companies
Political "relates to changes in national and political discourse causing or seeking voluntary commitments and standards."	You give us the framework, and we have the innovation and business to do all this. We can do it now; only you have to treat us the right way in terms of transparency. So, the transparency is beginning to be there, but it is not there yet. (C2) The world has agreed and is on track to develop a sustainable model for society. The UN SDGs are a good example of what that roadmap looks like. (C3)
Regulatory "relates to changes in legal frameworks/legislation."	There are a number of things that have to go right in the external environment for this to work, but if we do not push, it will not happen. So, if we look at it in that sense, the external factors are the legal framework. (C2) The impetus for that legislative package being prepared was the single-use plastics directive because that has a direct impact on our own products and sales …. So, it really was a call to arms for our company with regulation. (C3) Both customers and regulations are pushing us very strongly toward circularity, particularly in certain parts of the market. (C5) The cost of plastic packaging. … sometimes, the plastic costs double the cardboard, so the price of the final product is the same despite the cardboard having a higher base price. (C7)
Sociocultural "relates to the changes in social or cultural attitudes."	I would say the key driver is to be able to respond to the brand owner's demand for new solutions. (C1) Because if you ask consumers, consumers are willing to pay a premium. Packaging is a small amount of the overall price of what is inside the packaging anyway. A large number of consumers, a majority, say they are willing to pay more across the world. (C2) We get more and more questions linked to the CE from our customers, and even some suppliers want to understand whether they should sell their products to us in terms of using the CE in their marketing. (C3) A number of socially responsible individual investors have brought this up, but then a lot of the analysts and rating services platforms that investors use do have CE-linked questions that they want our company to respond to. (C3) Customers and regulations are pushing us very strongly toward circularity, particularly in certain parts of the market. (C5) A commitment to circularity is simply what the market requires … and consumers … want a more sustainable supply chain. And they see it, quite rightly, as important that businesses go further to ensure that the packaging they are being provided with can be used elsewhere. (C6) All our customers—it starts from the biggest customers actually—are asking for more environmentally friendly packaging, because they want to have some advantage relating to the end customer. They want something new, and they have an environmental image to protect. (C7)
Technological "relates to changes in the technological sector or other scientific breakthroughs."	We have new material that will hopefully go into mass production next year: a plastic made from 60 to 80% wood. (C2) In some cases, if you change the raw materials enough, you have to change the chemistry and the process. So we have several projects in the R&D pipeline to develop new products and solutions for customers, so it certainly involves new technology. (C3) First, there was the market pull, and then we had to find the technology. (C4)

the interaction between value-chain actors is ongoing, co-dependent, and possibly subject to nondisclosure agreements. The **generation** mechanism generates new products, materials, or processes and new business models addressing improved functionality and environmental impact; "*We are building more and more ideas and solutions for services to complement our actual products*" (C3). The example suggests that EEs pushing the CE may have an impact beyond the environmental side of CE and also target "slowing the loop" via improved durability. There are also different approaches to the **conservation** of resources, for example, "*enhancing the energy consumption in terms of output, recycling of material and … waste, and projects to enhance wind and solar energy usage*" (C1). This mechanism aims to reduce and optimize the amount of material used per unit, reducing the total amount of purchased raw material by recycling production off-cuts and increasing efficiency in production and machinery. The **resource substitution** mechanism relates to replacing existing raw materials or material input with something new. For example, with C8, "*We will produce water-based dispersion barrier boards which are an alternative to plastic lined products and would in a sense be different in that it is recyclable exactly in the same way as normal paperboard.*" The **resource expansion** mechanism is about increasing the availability or amount of a resource and optimizing, improving, and contributing to the recyclability of products is regarded as both easy and worthwhile "*Circularity for our product generally means recyclability, it can mean compostability, but the easy one to look at is recyclability.*" (C6).

While the above mechanisms are the most common within our data, some evidence suggests companies also utilize legitimation and demand substitution and uncertainty reduction mechanisms to benefit from EEs. Some companies seek to legitimate their CE projects *by saying* "*that the circular economy is a license to operate …*" (C5).

The data revealed that all three shaping, outcome enhancing and triggering roles were present. The shaping role was directly linked to the resource expansion mechanism thus stemming from all four types of CE related EEs; political, regulatory, sociocultural and technological. The outcome enhancing role was directly linked to the conservation and resource substitution mechanisms thus stemming from the regulatory and socio-cultural types of CE related EEs. The triggering role was directly linked to the conservation, combination and generation mechanisms stemming from the socio-cultural and technological types of CE related EEs. Fig. 1 in the discussion visualizes the relationships between types, mechanisms and roles.

5. Discussion

This study was set to identify CE related EEs and mechanisms within the food packaging industry. It uses Davidsson et al. (2020) EE framework to analyze the types of enablers and also the mechanisms and roles through which they shape and alter new ventures.

Following other studies using the EE-framework (Chalmers et al.,

Table 2
Examplary quotes from sustainability managers identifying types of mechanisms leveraged for CE.

External enabler mechanisms	Exemplary quotes from interviews with managers at each of the eight case companies
Combination "coupling with external resources or artifacts to provide functionality."	Both customers and regulations are pushing us very strongly toward circularity, particularly in certain parts of the market. And we see this clearly as a factor where we can differentiate and co-develop and co-create and also sort of strive to create the best innovation in the market. (C5) We are investing in things like paper lids for paper cups and fiber lids for paper cups. Those are innovations we are moving toward and working with others in the supply chain to achieve. (C6) … that is also a partnering concept, so we are not doing it by ourselves but in a partnership. Originally though, it was about utilizing waste back in the day, which has then developed continuously into what we have today. (C8)
Generation "allowing the creation of new artifacts (devices, functionalities, business models)."	We are also working on bringing in new material combinations and innovating possible new solutions and processes … where possible. (C1) We now have an app to calculate your packaging carbon footprint, and it gives you alternatives with lower carbon, lower water usage, and lower everything. (C2) It is a way of getting much closer to your customers and really understanding … what they need and really truly co-create and co-develop. I think some of those divisions that have worked longest with their customers to create more circular business models and value chains have found this extremely valuable for business development purposes and customer relationship enhancement. (C5)
Conservation "reduction in the amount of time required to perform an activity"	When it comes to designing and redesigning packaging solutions, one aspect, for example, utilizing the correct minimum amount of material, has been going on for years now. (C1) We now have a process where we take the waste back into the machine. Basically, this is a slight shortcut in the process, but it was happening. We retain the stuff. (C2) The entire industry, especially the Nordic paper industry, had invested significant amounts of money in innovations to move toward reducing the amount of polymer used. (C6)
Resource substitution "replaces one resource with another."	Another one is a big focus, not just on waste but on our biowaste raw materials … when we think about packaging materials, there is a strong drive to move away from fossil fuel-based materials into renewable materials, and this is a big driver for us. (C3) The driving force behind our company was the need to replace plastics, and plastics, in many cases, are anything but circular. (C4) Our plastic product for meat must be sealed. Now customers think this product should be more environmentally friendly, so we have to replace plastic packaging with cardboard. (C7)
Resource expansion: "increases in the amount of a resource that is accessible."	All our materials are developed so you can recycle them with paper board or packaging waste. That is another thing that differentiates ours from many other new materials; you need to create some kind of closed-loop system in order to recycle them. (C4) Circularity for our product generally means recyclability; it can mean compostability, but the easy one to look at is recyclability. (C6)

2019; Chen et al., 2020; Davidsson et al., 2021), we were able to identify the industry-specific drivers for the food packaging industry transitioning to CE. Davidsson et al. (2020) suggested that studies should be holistic by studying multiple enablers simultaneously and how they relate to one another. A common theme among the companies studied was that several types of EEs were in play simultaneously, pushing in the same direction. Similar to previous findings (Ranta et al., 2018), recycling and waste reduction approaches were the most common outcomes. In addition, in line with prior research cost reducing efforts (Kumar et al., 2019) were evident across the companies. However, we also identified efforts to build CE ecosystems (Aarikka-Stenroos et al., 2021). They result from actors realizing that circular systems need to function across organizational boundaries and deliver system-level outcomes that extend beyond what any actor could produce alone (Autio and Thomas, 2022). Much of the previous CE literature has focused on the relationship between regulatory efforts and CE advances (Geng et al., 2012; Mathews and Tan, 2011; Syberg et al., 2021). Our findings from the CE related EE perspective suggest that current European regulation could only support an incremental transition toward recyclability and reduction in material use. As such, we can only speculate whether improved recyclability also leads to higher recycling rates, but this was not the interest of this study. In other words, while there was a link between regulation advancing CE and the conservation and resource substitution mechanisms, it was only when other types of EEs were present concurrently and actualized through complex mechanisms that significant changes to the business model occurred or entirely new ventures appeared. However, political, customer and consumer pressures emerged convergently, pushing toward a broader CE concept, and particularly the entirely novel CE ventures appear to build on a complex mesh of mechanisms stemming from several types of EEs. In our study, all case companies mentioned sociocultural EE in the form of customer demand, and regulatory EE in the form of legislation such as the Single Use Plastics directive was mentioned by all but one. It was impossible to elicit whether one of the two types of EE was more important than the other. They were presented as arising concurrently by the interviewees whom, when questioned on this, said it was impossible for them to distinguish whether customer demand or legislation came first, and that both push in the same direction. Fig. 1 visualizes the relationships described in our research and how there is a high level of interaction to these relationships.

In the following we discuss the emerging insights in terms of the three potential roles for enablers in changing a venture: triggering, shaping, and outcome enhancing. The shaping roles of EEs range from shaping a specific product and product offerings to shaping the entire venture. The outcome-enhancing role is about achieving an equivalent output with less input or greater output from the same input. The triggering role is exemplified through the novel innovations offering companies opportunities to enter new markets.

5.1. Shaping

Mechanisms were either observed to be shaping or expected to shape the future of the companies in some way or another. That might be by incrementally assisting the transition of individual products, services, or

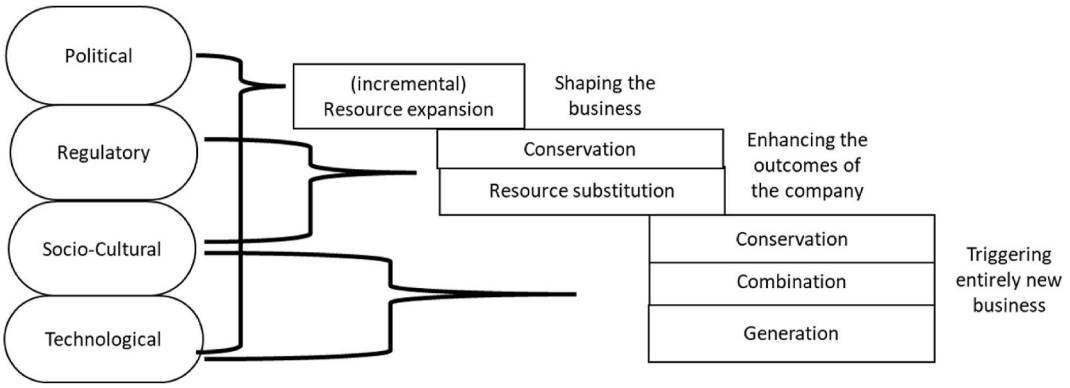

Fig. 1. CE related external enablers provoke different mechanisms that ultimately shape, enhance or trigger new businesses.

even product-service-software systems (Huikkola et al., 2022) to align with the CE concept. The resource expansion mechanism focused on recyclability stemming from regulatory and sociocultural CE related EEs. It shapes the products becoming part of closing the loop in a CE by being recyclable. Resource expansion is the result of increased recycling because more raw material is available on the market than if it had been landfilled or incinerated, and thus in addition to the virgin raw material resources there is the recycled raw material resource. When moving to mono-materials the recyclability is increased and thereby also the opportunity for increased recycling output. Moreover, the mechanism offers businesses a way to differentiate themselves and gain a competitive advantage in a CE model being adopted across sectors. Gaining a competitive advantage is a crucial aspect of pursuing CE (De Angelis, 2020), and first movers should reap the benefits of early adoption. This resource expansion mechanism creates more mono-material products by increasing recyclability and thus the volume of available (recycled) raw material, which, on the one hand, potentially reduces the number of different raw materials and raw material suppliers and, thus, complexity; although it might also increase dependency on a single supplier or a small group of them.

5.2. Outcome enhancing

Two mechanisms appeared to lead to outcome-enhancing roles, the conservation and resource substitution mechanisms. The conservation mechanism takes many forms that all play an outcome-enhancing role. For example, by reducing the amount of material going into each packaging design—known as lightweighting—there is a reduction in raw material usage. The mechanism can aid the reduction of raw material and also waste by looping production waste back into the raw material feed before it leaves the production hall. Such reductions in volumes of raw material demand and waste are crucial to CE. These efforts are closely interlinked with the resource expansion mechanism shaping the company because recyclability also enables the looping of post-production and post-consumer waste back into the raw material feed.

Furthermore, energy efficiency and reducing electricity consumption are conservation efforts that enable enterprises to meet both the customer demand for lower-priced materials and production costs and move closer to a CE. These measures are both supportive of a CE and can help reduce costs because they diminish raw material purchases and are a crucial yet understudied part of the CE literature (De Angelis, 2020). Therefore, this aspect of the transition to a CE does not necessarily have to be an extra cost to the company, particularly if R&D is considered a normal part of conducting business. The resource substitution mechanism took the form of replacing virgin raw materials with alternatives. The finding supports those of Schillebeeckx et al. (2022) that report a willingness to switch to environmentally friendly materials (Schillebeeckx et al., 2022). The alternatives ranged from industrial by-products to newly developed alternative raw materials and new applications of known alternative raw materials. These alternative raw materials were, in some cases, more expensive than the original, causing an increase in the price of the complete packaging. However, the more costly raw material price was counteracted at least to a degree by legislative initiatives such as the UK's plastic packaging fee and extended producer responsibility (ERP) schemes that reduce the producer's cost burden if the material is more easily recycled than a predecessor thus somewhat evening out the costs between the original and new raw material choices. The resource substitution mechanism was expressed to be closely linked to the recyclability of the resource expansion mechanism. Only if the alternative raw materials adhere to stricter recyclability requirements can they be considered a valid option. Both the conservation and resource substitution mechanisms play an outcome-enhancing role.

In something of an outlier case illustrating technology enabler creating an outcome enhancement, a newly developed technology enabled one of the companies to embed technology and create a new printing technology in-house. For example, this printing technology is being introduced to the majority of their products and is argued to be a game-changer that improves the continued recyclability of packaging by adding unique identifying information about each specific packaging. Improved recyclability is in high demand by customers, and this new technology is therefore playing an outcome-enhancing role across the company's products. Other similar technologies are being developed and made available and it is up to each company to evaluate if, how, and when to adopt such a technology.

5.3. Triggering

The triggering role was present across all case companies and was particularly evident where generation mechanisms had been activated and led to new and radical products entering markets where the companies had no presence prior to the emergence of these CE related EEs and mechanisms. Interestingly this finding does not align with prior research, which suggests that companies are risk-averse and unlikely to move into new markets (Kumar et al., 2019). Triggering entirely new CE businesses demands simultaneous EEs and a complex mix of mechanisms. The conservation, combination, and generation mechanisms are those directly linked to the triggering role and also impacted by the resource expansion and resource substitution mechanisms.

The combination mechanism leading to the diversion of production waste to producing new products such as shoes or clothes, or selling production waste to shoe and clothing manufacturers, is an example of how the complex CE value chain requires a focus on multi-stakeholder management (Mishra et al., 2019). It is possible to create a new revenue stream that delivers more profit than the cost savings arising from using the production waste as raw material in the same product line it came from. That offers an example of an outcome-enhancing role through the conservation mechanism described above (De Angelis,

2020).

The generation mechanism led one company to develop a business plan to offer consultancy to other manufacturers on how to become carbon neutral. In another case, an app used digital labeling to guide consumers to pick the product with the smallest carbon footprint. The innovation thus brings a whole range of new digital product opportunities. Digitization and moving away from physical products when feasible are also part of the journey toward CE. In this case, the costs of developing an app may represent a cost saving to the company compared to continuously printing labels, marketing material, information booklets and the like.

We found that the combination mechanism, specifically an increased collaboration along the value chain, appears to interact with the generation of innovative materials and solutions and the resource conservation efforts implemented. The EEs activate different mechanisms, yet in combination, add value to the company. Increased collaboration along the value chain may result in lower costs. These measures spur companies to add and extend product offerings while creating a competitive edge through differentiation. Through the combination mechanism, the value-chain co-creation of new product material occurred in a holistic manner from design, through production, to distribution.

6. Implications

The study contributes specifically to CE research and practice but also helps understand and advance the framework of EEs.First, while prior research on ways to advance the CE has focused on the regulatory policies of different regions, our study contributes by identifying an important boundary condition for regulation. While the support of the regulatory pillar is important (Ranta et al., 2018), additional enablers appear to push companies toward more advanced CE venturing. While our research is specific to Northern Europe, future research in this area might extend the scope to research the extent to which normative and cultural-cognitive conditions in different regions support or hinder the efforts implemented through regulation. Second, our findings suggest that packaging manufacturers are exposed to four EEs that push them toward circularity. The first is regulation at the European level, which sets stringent recyclability targets for packaging. The effect is evidenced in the search for easily recyclable packaging materials, such as packaging made of only one material or in which the different material components are easily separated. In addition, enterprises feel political pressure to follow voluntary standards, suggesting that companies seek not only to legitimate their business and comply with regulation but also seek to anticipate future legislative changes (Bansal and Roth, 2000). There is also sociocultural pressure toward CE from diverse stakeholders (Berrone et al., 2013), and firms must pursue securing a social license to operate amid sustainability demands (Demuijnck and Fasterling, 2016). As such, it is unsurprising that demands for circularity and sustainability innovation from customer companies drive product development. However, it was interesting to observe how much the end-consumer appeared to affect the choices made in these purely business-to-business firms. While consumer-facing companies have started to act (Bocken, 2014), and some prior studies suggest that consumer preferences for sustainability travel upwards in the value chain (Priem et al., 2012; Priem et al., 2018; Schillebeeckx et al., 2022), there is little indication that consumers influence firms that do not interact directly with them.

Our study also responds to the call by Davidsson et al. (2018) to empirically study the effects of multiple EEs occurring simultaneously. The identified CE related EEs shaped the business somewhat among all the companies surveyed, for example, by prompting projects to save packaging material used or switching to more recyclable materials such as mono-materials, avoiding labels and other non-recyclable add-ons, or replacing flexible packaging with rigid packaging material while maintaining the protective properties of the packaging. Our findings indicate that companies within the packaging industry move convergently, leveraging a fairly small range of different mechanisms and creating similar innovations in the transition to a CE when acting upon the same type of EE. This finding is not surprising; industries tend to mimic the actions of their immediate competitors (Spender, 1989). Importantly, however, the findings also illustrate that EEs have the potential to trigger more fundamental changes in business models and lead to entirely new business creation, even in new industry sectors.

Furthermore, our findings add empirical credence to the conceptual claims of the external enablement framework (Davidsson, 2020), suggesting that the same EEs can activate different mechanisms and play different roles depending on the agent. However, we suspect that in such cases, the EEs must match the firm's capabilities or the entrepreneurial agent's passions and motivations particularly closely. While there is still a lot to learn about the EEs themselves, future studies could scrutinize the links between the agent and the EEs, as we suspect that there is agent-related variation in which mechanisms the EEs ignite. However, every company mentioned their internal values as the core enabler of the transition to a CE, which aligns with prior research suggesting that companies care about sustainability not just because of external pressure and competitive reasons but also because of an ethical motivation (Bansal and Roth, 2000).

By revealing how the different enablers act and the outcomes they produce in the food packaging context, the findings also provide interesting insights for policymakers. For example, policies pushing the recyclability of packaging materials have generated an industry response that favors simpler mono-material packaging. For practitioners, the findings highlight that while CE-related EEs create an impetus for change, they can also provide opportunities for new business development and outcome enhancement and help to reshape more future-proof business models. Interestingly, an important message from the sustainability research appeared to have taken hold among the industry actors: All interviewees explicitly cited research suggesting that companies not actively pursuing sustainability will not survive in the long term.

Our research findings and interpretations are subject to food packaging context specific limitations of qualitative research, with a limited sample from a geographically limited area. Hence, future research in this area should include quantitative investigations to the extent to which normative and cultural-cognitive conditions in different regions support or hinder the efforts implemented through regulative processes. In addition, future research could look at the divide between companies with expressly stated internal values regarding CE and compare them to companies with different values and if this has an impact on actual actions taken. This could be studied through quantitative studies with more generalizable samples investigating which are the most salient enablers and mechanisms that are transforming the industry. Future studies could also seek to understand the lag in time between customer pressure taking form and regulative measures being implemented to learn how long of a delayed response a company could afford in its adoption of CE. Another avenue of future research could be to study whether companies utilizing certain CE related mechanisms outperform, long-term, over other mechanisms. This study is explorative and focused on the specific context of the food packaging industry and thus, the findings cannot be generalized across industries due to the study's qualitative nature and the findings have to be viewed within the regional context of the EU's focus on CE. The food packaging industry has been in focus and perhaps the political and consumer pressures are greater than in other sectors. EU regulation strongly promotes CE-related EEs, but policies vary worldwide. This study deliberately explored case companies that had declared themselves on a journey to CE, and they could thus be considered front-runners. We acknowledge that this may have impacted the results; however, this research aimed to specifically study how CE related EEs translate into actions in the food packaging industry. Therefore, a certain level of prior engagement with CE was considered necessary.

7. Conclusions

This study found that several CE-related EEs were in play simultaneously, collectively pushing companies to take action to increase the circularity of their products. Our findings further suggest that two or more mechanisms can interact and thus elicit both an individual firm response and an industry response. These findings support prior studies where recycling and waste reduction approaches were the most common outcomes followed by cost reducing efforts, but our study also identified efforts to build CE ecosystems. The findings suggest that companies within the food packaging industry often move rather convergently when pursuing CE, yet certain mechanisms provoke novel packaging innovations and trigger new ventures. By capturing the interplay of multiple EEs and mechanisms in the food packaging industry, the compounded role also adds a layer to the analysis and novelty of the research. By revealing how the different enablers act and what kind of outcomes they produce in the food packaging context, the findings also provide interesting insights for policymakers suggesting that several enablers and mechanisms should work in unison to support systemic change towards circularity.

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CRediT authorship contribution statement

Iben Bolund Nielsen: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, Project administration. **Henri Hakala:** Validation, Resources, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Iben Bolund Nielsen reports financial support was provided by Academy of Finland.

Data availability

Data will be made available on request.

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Publication III

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The Changing Activities of Circular Economy Frontrunners: What Do Food Packaging Manufacturers Do to Accommodate the Circular Economy?

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The Changing Activities of Circular Economy Frontrunners: What Do Food Packaging Manufacturers Do to Accommodate the Circular Economy?

Iben Bolund Nielsen

1 Introduction

Packaging is a fast-growing industry in which plastics play a significant part (Ada et al. 2023). The food packaging sector was valued at USD 363 billion worldwide in 2022, and that figure is expected to reach USD 512 billion by 2028 (Shahbandeh 2023). The food packaging industry faces regulatory and customer pressure to address the adverse effects of the high volume of single-use plastics (Nielsen and Hakala 2023). Single-use packaging (Jambeck et al. 2022) is associated with the global environmental challenge of plastic pollution (Phelan et al. 2022). On average, 70% of plastic waste worldwide is disposed of via landfill or incineration (EASAC 2020). This linear economy, where primary materials are extracted, utilized in production, consumed, and disposed of, turns natural resources into waste after a short use phase. Single-use packaging is symptomatic of that process (Neves and Marques 2022). The linear economy is being challenged by the developing concept of a circular economy (CE), which proposes a systemic economic shift to mitigate environmental degradation (Stahel 2016). These pressures compel the food packaging industry to implement CE principles, increasing the demand for innovative and scalable novel food packaging solutions (Bor et al. 2024).

The CE concept has gained traction across several realms of research, marked by a dramatic increase in CE-related articles since 2016 (Merli et al. 2018). Transitioning from a linear economy to a CE represents a systemic shift, where natural resources become secondary resources instead of waste and are used and produced more sustainably by designing out waste from the production processes (Agyemang et al. 2019). In a more radical interpretation, CE is posited as a solution to environmental degradation through a change in economic logic where sufficiency replaces

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production (Stahel 2016). However, the CE concept has been defined in a variety of ways (Korhonen et al. 2018a; Kirchherr et al. 2018) by academia, think tanks, and political bodies (Merli et al. 2018). The definitions commonly include an aim of sustainable development, with reuse, recycling, value maintenance, and resource efficiency as its key pillars (Kirchherr et al. 2023).

Recent CE research has moved from exploratory, conceptual studies to examining the practical implementation of CE concepts (Mahanty et al. 2021), and research findings have shown that successful implementation of a CE necessitates the involvement of a variety of stakeholders for the successful implementation of circularity (Mishra et al. 2019). The CE also presents a critical sustainability challenge for the packaging industry (Ada et al. 2023), and research into circular food packaging is expanding (Zhang et al. 2022).

Interest in CE and related initiatives is not confined to academia. For example, the European Union (EU) has introduced legislative measures, policies, and strategies since 2015 to support and encourage the transition to a CE for individuals, organizations, and countries. One key initiative has been the European Green Deal, which set clear expectations for the impact and aim of any CE initiative to reduce greenhouse gas emissions (European Commission 2015). Specific measures such as the Single Use Plastics Directive (European Commission 2018), the Circular Economy Action Plan, and the Packaging and Packaging Waste Regulation set goals for the continuously expanding packaging industry to address environmental challenges. Consequently, firms in the food packaging industry must adapt to remain in business.

Owing to the pressures from policy changes and consumers, the food packaging industry is evolving, prompting an increasing demand for knowledge on best practices around circular packaging (Palazzo et al. 2023). This research addresses this need and explores how the activities of self-proclaimed CE frontrunners in the food packaging industry are changing as they work toward a CE. The aim is to explore data from international food packaging industry firms to narrow the knowledge gap on managerial activities supporting and accelerating a CE. The research question is: *What activities are changing in CE frontrunner firms implementing CE-related innovations in the food packaging industry?*

The case firms' operations are business-to-business (B2B) oriented, based in Finland, and describe themselves as early adopters of CE principles. Data were collected through semi-structured interviews and analyzed following an inductive research methodology. The semi-structured interviews were conducted with individuals whose roles directly or indirectly influence sustainability-related decision-making and the implementation of related activities, including some that are not publicly known.

The remainder of the chapter is organized as follows: a summary of the extant literature on innovation and CE is followed by the methodological section describing the case context and design. The findings are then presented in detail, followed by a discussion that advances the understanding of how food packaging innovation contributes toward circularity. Finally, the last section provides implications and a call for further research.

2 The Circular Economy and Innovation

The primary objective of the CE is to achieve sustainable development and fundamentally shift the current economic system (Kirchherr et al. 2023). It thus represents a new sustainability paradigm (Geissdoerfer et al. 2017). As the CE is an umbrella concept covering diverse goals—from reducing material use to reuse, recycling, and different business models—the shift toward CE can be advanced through CE innovations and transition pathways. Therefore, CE comprises complex and sometimes contradictory components. For example, in the context of food packaging, replacing lightweight plastic items with heavier reusable or recyclable materials can create adverse environmental effects from increased material usage (Sundqvist-Andberg and Åkerman 2021).

Furthermore, poorly developed reuse logistics systems can lead to increased use of non-recyclable materials and transportation, complicate logistics, and jeopardize food safety (Coelho et al. 2020). However, research suggests that reusable food packaging has environmental benefits. Life cycle assessments (LCAs) show the largest portion of greenhouse gas emissions stem from the manufacturing and end-of-life phases of packaging. Adopting reusable over single-use food packaging can radically reduce, and sometimes eliminate, those emissions (Camps-Posino et al. 2021).

The circulation of materials, particularly recycling, has become the leading strategy in the transition to a CE (Ghisellini et al. 2016). The EU, for example, appears to be focusing on regulating the circulation and end-of-life handling of (waste) materials rather than reducing the overall resource demand or production volumes (Ranta et al. 2018). The failure to address the root cause of increasing material use, that is, rising production volumes, undermines the effectiveness of CE policies. While CE initiatives can reduce the extraction of primary resources per production unit, their impact may be negligible compared to the effects of overall economic growth (Bianchi and Cordella 2023).

Existing CE research can be divided into three overarching themes: changing social and economic dynamics, industrial symbiosis, and circular process implementation (Merli et al. 2018). This research focuses on the circular process implementation, that is, the corporate-level activities in the transition from a linear economy to a CE. The adoption of CE innovations is significantly influenced by purchasing, value chain management, and collaboration (Palazzo et al. 2023). Additionally, one bibliographic review found eco-innovation and innovation in business models highlighted in CE research (Sehnem et al. 2022). However, research at the intersection of innovation and CE has been fragmented (Suchek et al. 2021). The mentioned research, as well as other studies (Geels et al. 2023; Schaltegger and Wagner 2011), signals that there has not been extensive attention paid to the question of how corporate innovations contribute to the CE transition, despite innovation being critical for such a systemic shift (Freeman and Perez 1988). It is, therefore, essential to explore how CE and innovation intersect in practice to reduce the

knowledge gap and understand the nuances of how firms can advance the transition to a CE.

Innovation is traditionally defined as the initial commercial application of an invention to a market (Greenacre et al. 2012). More specifically, in the context of CE, York and Venkataraman (2010) define environmental innovation as *"technological advancements that allow for reduced environmental degradation, the formation of new markets, and the distribution of information to consumers"* (York and Venkataraman 2010). For firms to benefit from innovation, including environmental innovation, they must excel at product innovation, business model innovation, and understanding business design options, customer needs, and the direction of technology development (Teece 2010).

Business models can facilitate innovation by defining the value for customers and convincing them it is worth paying for (Teece 2010). The growth of circular business models emerged after the introduction of the CE concept in academia (Geissdoerfer et al. 2020). Early research identified four circular business models: (1) using less material per product, (2) extending product life, (3) reusing materials, and (4) reviving natural resources (Bocken et al. 2016). A later review presented four generic strategies for circular business models: (1) cycling, (2), extending, (3) intensifying, and (4) dematerializing (Geissdoerfer et al. 2020).

In addition to business models, circular business strategies are also important for the emergence and adoption of novel CE innovations. They can be examined at three different levels: product innovation, process innovation, and organizational innovation (Tohănean et al. 2020). Producing innovative products, processes, or business models requires firms to search for new knowledge differently depending on the innovation type (Snihur and Wiklund 2019). Collaborations can bring new knowledge to facilitate CE innovations in firms (Kobarg et al. 2019). Collaborations among a variety of stakeholders are particularly important to establish a circular business ecosystem (Aarikka-Stenroos et al. 2021). Collaboration may also be utilized as a strategic move to communicate an alignment of values to customers (Todeschini et al. 2017).

This paper employs the above insights derived from the intersection of CE and innovation research. It then applies them to the food packaging industry to understand and advance knowledge on CE-related innovation activities in food packaging. The food packaging industry is relatively complex to study from a CE perspective (Oldfield et al. 2018). Food packaging helps reduce food waste, food loss, and associated greenhouse gas emissions (Siracusa et al. 2014). However, food packaging can become litter, relies heavily on fossil-fuel-based plastics, and is often difficult to recycle due to the variety and combinations of materials used (Geueke et al. 2018). To date, research on innovation in circular food packaging has largely fallen into two categories: technical aspects of food packaging materials and food packaging waste management (Zhang et al. 2022). Similarly, policy measures have focused on the beginning and end-of-life stages of food packaging (Sundqvist-Andberg and Åkerman 2021) rather than on the practices of firms producing and using the packaging.

An environmentally damaging aspect of food packaging is the primary resource consumption, such as natural gas and crude oil (Siracusa et al. 2014). Reducing primary resource consumption can be achieved by using less raw material to produce the same output, thereby reducing the environmental impact per unit produced (Hekkert et al. 2000; Schmidt et al. 2020). Utilizing secondary resources from recycling is another way to reduce primary resource consumption (Bianchi and Cordella 2023). Material efficiency activities and related cost reductions are key to CE-focused business case development (Rosa et al. 2019). Reducing material and energy usage often reduces costs, too, and if there are economic benefits, organizations are more likely to adopt CE practices (Gusmerotti et al. 2019). Investment has significantly improved resource efficiency (Lehmann et al. 2022) but not enough to reduce environmental degradation, which requires a combination of investment and innovation (Lehmann et al. 2022).

3 Methodology

3.1 Research Context

This study employed a case study research method to examine how CE frontrunners in the food packaging industry drive innovation to advance the CE. Case studies serve the purposes of this research well since understanding the activities changing during the transition to a CE can only be studied through empirical evidence. The case study methodology enabled the researcher to understand the specific subject in a particular context and is thus particularly well-suited for investigations into an in-depth phenomenon (Yin 2014), such as the transition to a CE.

This study of frontrunners in the food packaging industry is based on empirical material collected from eight firms producing food packaging operating in Finland's business-to-business (B2B) market. The eight firms were chosen based on being (1) a food packaging manufacturer, (2) a self-proclaimed CE frontrunner, (3) based in Finland, and (4) an international operator. The beverage sector is excluded from the study because it has a very specific setup in terms of circulation of packaging in many cases and is regulated differently from other food packaging.

The selected firms actively pursue CE principles and are early adopters of them according to their own online and printed media presence. Established firms, start-ups, large public enterprises, and privately owned firms are included in the dataset. Annual revenue ranges from EUR three million to EUR 11 billion among the firms that publish financial statements. Some privately held or smaller firms included in this research do not publish financial figures. The number of employees ranges from approximately 20 to 16,600 among the firms where these figures are publicly available. The firms differ in terms of where responsibility and accountability for sustainability sit within the organization and the type of food packaging material they

use or aim to change to advance the CE. However, all the selected companies operated with different types of fiber-based and plastic-based packaging.

3.2 Data Collection and Analysis

The data collection started with identifying food packaging-producing firms pursuing CE goals. The main sources of information during this phase were industry experts, news outlets, LinkedIn, and company websites. An integrated approach to analysis and interpretation was followed to capture the interrelatedness of elements (Dubois and Gadde 2002). Eight semi-structured interviews were conducted with the selected firms in the second phase. The interviewees held key leadership roles in the management teams of their respective employers and had responsibilities around sustainability. All interviews were conducted online and lasted up to 1 h. The interviews were recorded and immediately transcribed. Each transcript was coded following a rigorous inductive research method as described in Gioia et al. (2013), in which the interviewee-centric terms were first identified from the transcripts, then reviewed to derive concepts and themes, and finally grouped into aggregate dimensions (Gioia et al. 2013). In this case study, the guiding question of the analysis was how the CE frontrunners of the food packaging industry are changing their activities in the course of the transition to a CE through innovation.

Table 1 visualizes the analysis process from the data sources, selected quotes, and first- and second-order codes to aggregate dimensions. The first-order codes were grouped into concepts using the interviewees' terminology; 14 first-order concepts were identified. The second-order coding identified five themes derived from the first-order concepts, and from the five second-order themes, two aggregate dimensions were identified. The first second-order theme, *collaboration*, is derived from the first-order concepts of *co-development*, *co-creation*, *collaboration*, and *partnerships*. The interviewees use these first-order concepts to describe how the relationships within and along the value chain are changing, thereby allowing the firms to pursue CE. The next second-order theme, *business development*, is derived from the first-order terms *material combination*, *new solutions and processes*, *awareness raising*, and *improved customer relationships*. The interviewees use these first-order concepts to describe what they are doing differently to progress the CE compared to a conventional linear setup. The two second-order themes, *collaboration* and *business development*, form the aggregate dimension of *business practices*. This aggregate dimension deals with foundational aspects of how the firms envisage bringing innovative food packaging to market.

The third second-order theme, *material innovation*, is derived from the first-order concepts *switching to renewable materials and replacing plastic materials*. These first-order concepts describe specific product-level changes to advance the CE. The fourth second-order theme, *material efficiency*, is derived from the first-order concepts, *minimum viable amount of raw material while maintaining functionality and adding post-production scrap back into the raw material feed*. These

Table 1 Coding and data structure

Data source	Exemplary quotes	1st order concepts	2nd order themes	Aggregate dimensions
Semi-structured interviews with managerial roles with responsibility for sustainability	Both customers and regulations are pushing us very strongly toward circularity, particularly in certain parts of the market. And we see this clearly as a factor where we can differentiate and co- develop and co-create and also sort of strive to create the best innovation in the market. (C5)	Co-development and co-creation for improved innovation	Collaboration	Business practices
	We are investing in things like paper lids for paper cups and fiber lids for paper cups. Those are innovations we are moving toward and working with others in the supply chain to achieve. (C6	Collaboration along the supply chain		
	… that is also a partnering concept, so we are not doing it by ourselves but in a partnership. Originally though, it was about utilizing waste back in the day, which has then developed continuosly. (C8)	Partnerships rather than single-company innovation		
	We now have an app to calculate your packaging carbon footprint, and it gives you alternatives with lower carbon, lower water usage, and lower everything. (C2)	Awareness raising	Business development	
	It is a way of getting much closer to your customers and really understanding … what they need and really truly co-create and co-develop. I think some of those divisions that have worked longest with their customers to create more circular business models and value chains have found this extremely valuable for business development purposes and customer relationship enhancement. (C5)	Improved customer relationship		
	We are also working on bringing in new material combinations and innovating possible new solutions and processes. (C1)	Material combinations and new solutions and processes		

(continued)

Table 1 `(continued)

Data source	Exemplary quotes	1st order concepts	2nd order themes	Aggregate dimensions
	Another one is a big focus, not just on waste but on our biowaste raw materials … when we think about packaging materials, there is a strong drive to move away from fossil fuel-based materials into renewable materials, and this is a big driver for us. (C3)	Switch to renewable materials	Material innovation	Packaging materials practices
	The driving force behind our company was the need to replace plastics, and plastics, in many cases, are anything but circular. (C4)	Replace plastics as a material		
	Our plastic product for meat must be sealed. Now customers think this product should be more environmentally friendly, so we have to replace plastic packaging with cardboard. (C7)	Replace plastics with cardboard		
	When it comes to designing and redesigning packaging solutions, one aspect, for example, utilizing the correct minimum amount of material, has been going on for years now. (C1)	Reducing amount of material used for same functionality	Material efficiency	
	We now have a process where we take the waste back into the machine. Basically, this is a slight shortcut in the process, but it was happening. We retain the stuff. (C2)	Recycle post-production scrap as raw material		
	The entire industry, especially the Nordic paper industry, had invested significant amounts of money in innovations to move toward reducing the amount of polymer used. (C6)	Reduction in raw material		
	Turning packaging into mono-materials, not strictly for recyclability but downgauging. (C2)	Recyclability	Material recirculation	
	All our materials are developed so you can recycle them with paper board or packaging waste. That is another thing that differentiates ours from many other new materials; you need to create some kind of closed-loop system in order to recycle them. (C4)	Recyclability		
	Circularity for our product generally means recyclability; it can mean compostability, but the easy one to look at is recyclability. (C6)	Recyclability and compostability		

first-order concepts describe the move away from the conventional linear setup. Finally, the fifth second-order theme, *material recirculation*, is derived from the first-order concepts of *recyclability* and *compostability*. These first-order concepts explain the changes relating to a product's end-of-life phase. The three second-order themes, *material innovation*, *material efficiency*, and *material recirculation*, form the aggregate dimension *packaging materials practices* due to their common function of describing actions that must continuously improve.

4 Activities That Are Changing While Pursuing Circular-Economy-Related Innovations

This section extends our understanding of how packaging industry practices are changing as they adopt CE innovations with reference to the five identified themes. The five themes are (1) collaboration, (2) business development, (3) material innovation, (4) material efficiency, and (5) material recirculation. None of the studied firms reported engaging in eliminating single-use packaging waste or extending the life span of packaging by innovating new solutions to fulfill the same function.

The first of the five themes is *collaboration* along the value chain. The firms work closely with their value chain partners, increasingly so compared to the time before the focus was on circularity. Although the firms have different approaches to these collaborative efforts, the increased interdependence indicates a shift in attitudes. This shift facilitates co-development, co-creation, collaboration, and partnerships along the entire value chain. Such collaborations are described as central enablers in the transition to a CE because customers and suppliers come together for a common purpose. For some firms, this collaboration is a requirement from customers; for others, it is a natural development and a more navigable setup for a CE. In this CE setup, firm-specific knowledge may be shared, and new solutions can have multiple owners. This novel level of transparency and trust enables a new level of insight that can be addressed in the transition to a CE. One interviewee commented on the new relationships along the value chain: *"One step forward and one step back along the value chain is quite a natural way for us to discuss the possibilities of future developments."* (C1). Such collaboration supports rapid innovation because the parties involved continuously communicate throughout the process, thus avoiding potentially slow and costly prototype reiterations. Other financial aspects include transparency regarding necessary investments, as indicated by C6: *"Investment is needed to achieve the CE goals of the increased value chain collaboration."* These interdependent relationships with customers can act as a powerful motivator for upstream entities in the value chain owing to accelerated feedback on new inventions.

The interdependent relationships impact material innovation and material recirculation. The customers communicate the desired level of material circulation they aim to achieve. The material recirculation, in turn, impacts material innovation

because it must meet the material circulation requirements. The interdependent relationships with upstream suppliers also impact material innovation through the communal discovery and testing of novel raw materials. The increased collaboration also impacts elements of business development and leads to collaborative efforts to raise awareness and improve processes and distribution patterns.

The second theme is *business development*. The data indicate that firms amend their business development activities to embrace CE. Business development activity changes include (1) combining materials in new ways, (2) creating new solutions, (3) improving processes, (4) entering new markets, and (5) raising awareness through software applications showcasing the environmental impact of food packaging for customers. These business development activities change gradually, reflecting shifts in the firms' value propositions. The gradual shift allows the firms to gauge customer interest and approve the adoption of potentially costly technologies. Changes to value propositions may also mean entering new markets peripheral to the food packaging industry, as explained by an interviewee:

> Until 18 months ago, we produced no paper straws, and now we do. I have no idea what our market share is, but we now have a market share of straws, and we did not have a market share before. We are investing in things like paper lids for paper cups and fiber lids for paper cups. Those are innovations we are moving toward and working with others in the supply chain to achieve. (C6)

Multiple interviewees (C1, C2, C5, C6, and C8) stated that they are convinced adopting CE activities is necessary to ensure they will be granted a license to operate in the near future. Therefore, firms must re-invent themselves and review how they conduct their business to advance the CE, which requires a degree of farsightedness. The changes to business development practices are described as significant by the interviewees. Their firms review and question existing activities in light of CE principles.

Business development activities can be impacted by the other four themes: material efficiency, collaboration, material innovation, and material recirculation. However, material efficiency does not impact business development in the same manner as the other three themes. The absence of material efficiency could impact business development, but material efficiency alone was not reported to change business development activity. That is because most of case companies had a long-established goal of pursuing efficiency. Collaboration impacts business development as both a driver and enabler for new and more CE-oriented solutions because customers drive the demand and suppliers enable it. Additionally, in some cases, collaboration impacts aspects of business development, leading to entering new markets if in partnership with customers. Material innovation acts as an enabler of new solutions, better material combinations, and new market entry. Material recirculation acts as a minimum requirement for new business development.

The third theme is *material innovation*. Firms are inventing new material solutions by switching to renewable materials and replacing plastics with materials more suited to CE principles. Some firms are replacing fossil fuel-based plastics with plastics from bio-based materials, and others are moving away from plastic

altogether and replacing it with cardboard or other non-plastic materials. Introducing new materials appears to be associated with higher costs than well-known materials such as conventional plastics. One interviewee expressed how their firm has adopted new materials and considered the cost aspect: *"We have also made plastics from biomaterials. We have tested a lot of biomaterials, but the prices are high, and the customer will not be willing to pay more if they do not get significant benefits."* (C7) However, involving the customer in material innovation processes appears to help secure customer acceptance of the related cost increases.

Material innovation is also impacted by collaboration along the value chain because customers request, or demand, materials made from renewable raw materials and or move away from using plastic materials. Customers participate in and push for material innovation through collaboration, but suppliers have a role to play, too. Suppliers provide technical and material insights and hold key information on supply availability and price points. Material innovation is significantly influenced by the circulation potential of the packaging material as a result of both legislation and customer demand for improved recyclability. However, firms could deviate from the recyclability and compostability requirements if the material innovation was perceived to be better for the environment, even if the chosen material was not recyclable or compostable. Material innovation, as such, was described by the studied firms as a key driver of changes in the existing food packaging markets. However, replacing environmentally challenging materials with more environmentally friendly options can be very problematic in some food categories.

The fourth theme is *material efficiency*. This study finds that firms addressing material efficiency reduce raw material usage in two ways. First, reducing the amount of material utilized while maintaining the same functionality makes the product lighter than earlier or standard versions. Second, it is necessary to reduce raw material consumption by utilizing post-production scrap material from the product line and adding it back into the raw material feed. That process also reduces production waste that must later be disposed of. Reducing waste from the production line aligns with CE principles and simultaneously reduces the costs of waste disposal. These approaches reduce the overall demand for raw materials while supplying the market with the same amount of packaging output. These changes to the production process are continuous and incremental to ensure that product quality is not compromised. Although material efficiency is described as a response to external pressure, economic considerations have impelled some firms to undertake such activities for a longer period. Material efficiency aims to reduce the total amount of raw material purchased while maintaining output volumes because, all other things being equal, doing so will reduce the environmental impact per unit. Material efficiency does not appear dependent on other themes in the transition to a CE, which also explains how material efficiency can be a long-established process even prior to the focus on CE. However, the absence of material efficiency can hinder some aspects of business development.

Finally, the fifth theme is *material recirculation*. Firms dedicated to the CE should ensure materials can circulate through technical recyclability and natural or industrial compostability. Firms are improving recyclability by minimizing the amount of different materials used in one packaging item. Another route is to ensure the end-consumer can separate the different component materials easily. In addition, all the materials used should be recyclable in existing and widely recognized recycling streams.

One interviewee precisely described one of the changes implemented to improve the recyclability of products:

> We use water-based dispersion barriers instead of, for example, using polyethylene coatings, and these barriers really can be repulped in a conventional recycling plant instead of in processes that can separate plastics at special recycling plants. (C8)

Compostability, conversely, means that the material decomposes under a defined set of circumstances fulfilled in a designated composting facility or in nature under natural conditions. The respondents sometimes used the terms compostability and recyclability synonymously, whereas the EU defines composting as an end-of-life process. Compostability is often not considered part of CE because as the material degrades, CO_2 is emitted. However, the company representatives interviewed did consider it a CE-related innovation.

Material recirculation impacts the material innovation and business development themes and is, in turn, impacted by the collaboration and business development themes. The material recirculation theme dictates the minimum requirement for the recyclability or compostability of packaging according to either customer or legislative demands. Improving recyclability in this context focuses on innovating or replacing non-recyclable materials with recyclable ones rather than in terms of improving recycling processes. Such new materials emerge under the material innovation theme or from the business development practice of dealing with material combinations. Collaboration impacts material recirculation because customers demand a certain level of recyclability or compostability, and suppliers enable that. Business development impacts material recirculation because new geographical markets or product markets may have specific requirements for circulation potential and because of differences in recycling and waste-collection streams.

Material recirculation was the CE-specific aspect that the industry has worked on the longest and has the most experience with.

5 How Activities Work Together

The previous section introduced five different categories of activities that CE frontrunner companies are changing, and the dynamic relationship between those activities. Figure 1 illustrates these categories, the 14 activities identified, and the relationships between the categories. The following section examines these findings

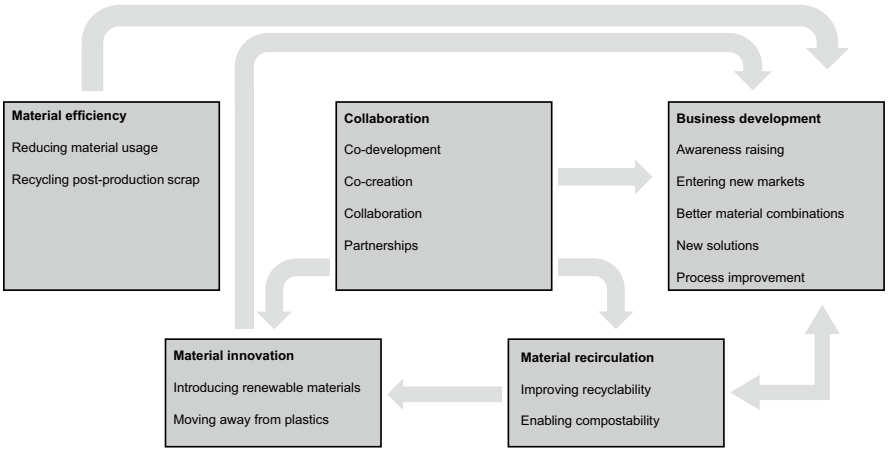

Fig. 1 Summary of the relationships between the five different types of changing activities

and discusses how they contribute to previous research on CE and its implementation.

Two related findings are that material efficiency activities are typically improved independently within the firms rather than in collaboration with customers or suppliers. Such material innovation seeks to reduce primary resource consumption simultaneously. Both material efficiency and material innovation rely on reducing primary resource consumption or replacing primary resources with alternatives, including secondary resources, renewable resources, or less environmentally damaging resources.

Material efficiency initiatives were undertaken prior to the focus on CE principles. Material efficiency improvements both reduce cost and eliminate waste during production. Cost reductions appear to be the most important driver of CE-focused sustainable development (Rosa et al. 2019), and reducing primary raw material consumption is key to reducing the environmental impact of food packaging (Siracusa et al. 2014). It is, therefore, particularly interesting to note the reasoning behind material efficiency efforts since the process of reducing the amount of material was described as one of continuous improvement that started long before circularity became an ideal. Therefore, it could be argued that material efficiency is not an activity that changes due to a transition to a CE; however, it is an essential element that benefits both the bottom line and the CE. Although material efficiency alone is not enough to significantly advance the transition to a CE, it has a natural fit with it. It reduces cost at the same time, which aligns with prior research indicating firms pursuing economic benefits are more likely to adopt CE principles (Gusmerotti et al. 2019). Prior research establishes that a shift toward more CE-focused processes reduces the extraction of primary resources marginally compared to the impact of overall economic growth. Specifically, estimates show that the primary resources extracted annually linked to economic growth are approximately four times the resource usage avoided by CE initiatives (Bianchi and Cordella 2023).

On the other hand, material innovation appears to be a slow and expensive process. If a new material replaces a conventional one, the littering issue persists, although potentially with less environmental impact. As such, there are arguments that the largest environmental benefits can be achieved by designing packaging to reduce the impact of littering (Anand et al. 2024).

Another interesting finding is that collaboration is the central driver of changing activities during the shift toward the CE. Collaboration links with material innovation, material recirculation, and business development. Collaboration along the value chain drives demands for material recirculation and material innovation and nurtures business development. However, we found little evidence of business model innovation. The novel business developments resulted in product innovation, where new material innovation was applied to products the firms had not produced before. The only evidence of business model innovation was in the efforts to raise awareness that could allow the firms to capitalize on knowledge-sharing digital solutions in the future. Arguably, the complexity of the innovation (Tohănean et al. 2020) required for CE business model innovation persuades firms to choose a gradual approach, starting with product and process innovation alongside increased collaboration that may become the basis for CE business model innovation in the future.

The studied firms seek external knowledge by engaging in different forms of collaboration along the value chain. The external knowledge accessible through the increased collaboration differs depending on the goal of the collaboration, a finding that aligns with prior research (Mishra et al. 2019; Snihur and Wiklund 2019; Tohănean et al. 2020). Collaboration with customers drives higher material recirculation demands than regulation prescribes. Collaboration with suppliers enables material innovation by utilizing external knowledge to develop more sustainable and circularity-friendly materials. The collaboration theme corroborates prior findings indicating firms seek external knowledge to spur innovation (Snihur and Wiklund 2019) and confirms prior research establishing that CE is enabled through collaboration with multiple stakeholders (Mishra et al. 2019). The multi-stakeholder approach is also embedded in the definition of CE the current research subscribes to, in which cooperation between producers, consumers, and other actors is necessary for the efficient utilization and flow of materials (Korhonen et al. 2018b). Firms must innovate to become more sustainable and more profitable. However, innovation also poses risks (Tohănean et al. 2020), and this study's findings indicate that firms seek to mitigate risk through increasing collaboration.

Business development activities affect material recirculation activities when firms enter new markets and have new solutions under development. Product, process, and business model innovation must be viewed in light of the company itself and the relevant industry (Snihur and Wiklund 2019). That perspective is essential because introducing innovations requires specific capabilities from the firm and customer acceptance.

The findings of this research indicate material recirculation activities impact both material innovation and business development by setting minimum requirements for the circulation potential of novel materials, material combinations, and new solutions. These findings contrast with those of prior research suggesting that

the CE tends to be misinterpreted as merely an approach to better waste management (Ghisellini et al. 2016). The findings of this study suggest that an acceptable level of waste management is a minimum requirement for further CE initiatives and is pursued in combination with material innovation activities and new business development opportunities.

The interview material indicates material innovation impacts business development by facilitating access to new markets with novel solutions. Material innovation is often technology-dependent, and as that technology is constantly evolving, it supports innovations (Rajput and Singh 2019). Technology has enabled some of the case firms to gather and display higher-resolution data, which one company leveraged as a platform for raising awareness.

Finally, this study confirmed that despite interviewees mentioning circular business models in the context of future ideas to pursue, they were not being explored. Furthermore, although reduction and recycling activities were implemented, none of the firms worked with reusable packaging options. Moreover, although circular start-ups tend to embrace higher levels of circularity than incumbents (Henry et al. 2020), none of the data suggested that the firms investigated partnered with start-ups despite the strong focus on collaboration and partnerships.

6 Implications

The transition to a CE in the packaging industry is a complex process. To grasp the systemic character of a CE transition, it is crucial to investigate how different changes within a system interact to boost systemic change. This study explored how activities are changing and the dynamic relationships between them. The majority of changing activities impact one another, and the central driver appears to be the increased collaboration with both customers and suppliers. A systemic transition from linear to circular is a radical shift (Ghisellini et al. 2016), and innovative products and business practices are necessary factors if such radical and disruptive shifts are to occur (Freeman and Perez 1988).

Prior studies have suggested that to attain a CE transition, firms must excel in various fields, including product innovation, business model design, and technology development (Teece 2010). The findings of this study show firms employing various ways to internalize and pursue CE innovations. This research identified 14 activities related to five different themes that self-proclaimed CE frontrunners in the food packaging industry are changing. The findings contribute to a growing body of literature on CE in business management and show that firms can employ various ways to internalize and pursue CE, depending on their broader business strategies, available resources, and collaboration networks. Three diverse pathways can be identified. One pathway is to target reducing CO_2 emissions by prioritizing cutting the use of fossil fuel-based material and material usage in general, which leads to a simultaneous reduction in material costs. The second pathway is based on the evaluation of alternative material options that fit the CE model based on compatibility

and cost, both of which may change over time. The third pathway focuses on improving recyclability despite the different recycling options between countries. To be genuinely innovative, all three pathways should emphasize partnering with established supply chain actors and born-innovative circular start-ups.

This study is limited by its focus on self-proclaimed leaders in implementing CE principles in Northern Europe. While it provides insight into the actions of frontrunners, other studies might investigate how more conservative packaging firms cope with the external pressures to introduce circularity and sustainability (Nielsen and Hakala 2023). Scholars might also explore, map, and review the innovative and novel measures implemented by the management of the largest food packaging manufacturers.

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Publication IV

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3

ADAPTATION OF ARTIFICIAL INTELLIGENCE BY START-UPS FOR A DATA-DRIVEN CIRCULAR ECONOMY

Evidence from Multiple Case Study in Finland

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3

ADAPTATION OF ARTIFICIAL INTELLIGENCE BY START-UPS FOR A DATA-DRIVEN CIRCULAR ECONOMY

Evidence from Multiple Case Study in Finland

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1 Introduction

The goal of a circular economy (CE) is to preserve the utility and value of products, components, and materials for as long as possible by "slowing, closing, and narrowing" production loops (Bocken et al., 2016). Transitioning to a CE involves a systemic shift aimed at mitigating the effects of the linear economy, building long-term resilience, creating economic and business opportunities, and delivering environmental and social benefits (Ellen MacArthur Foundation, 2015). In other words, it requires a radical change in business model (BM). Current research on circular business models (CBMs) is mostly centered around well-established companies and large corporations with only few studies focused on circular start-ups (Henry et al., 2020). The CBMs of incumbent firms and start-ups differ; incumbents can shape the ecosystem they are part of but may lack the flexibility of entrepreneurial start-ups in seizing opportunities and fostering groundbreaking innovations (Suchek et al., 2022). Entrepreneurs spot and exploit new opportunities by orchestrating novel combinations, leading to new products, production methods, raw material sources, markets, and organizational structures.

Circular entrepreneurship is described as the act of discovering and capitalizing on opportunities in the CE sector (Zucchella and Urban, 2019). As CE is seen as a strategy for achieving specific sustainability goals (Geissdoerfer et al., 2020), circular entrepreneurship can be embodied by "born-circular" companies. These are young enterprises specifically established to offer circular value propositions and explore opportunities in the CE sector (Zucchella and Urban, 2019). New circular businesses help address environmental issues by introducing new eco-friendly products, services, and institutions, actions that may pose greater risks to established companies (York and Venkataraman, 2010). However, research into the role of entrepreneurship in the transition towards a CE is still in its early stages and is a recent development (Heshmati, 2015).

At the same time, the fast and recent advancements in digital technologies (DTs) have elevated the importance of data and analytics in corporate strategies, leading to the assertion that "data is the new oil" that can be refined to unlock unparalleled value (Manyika

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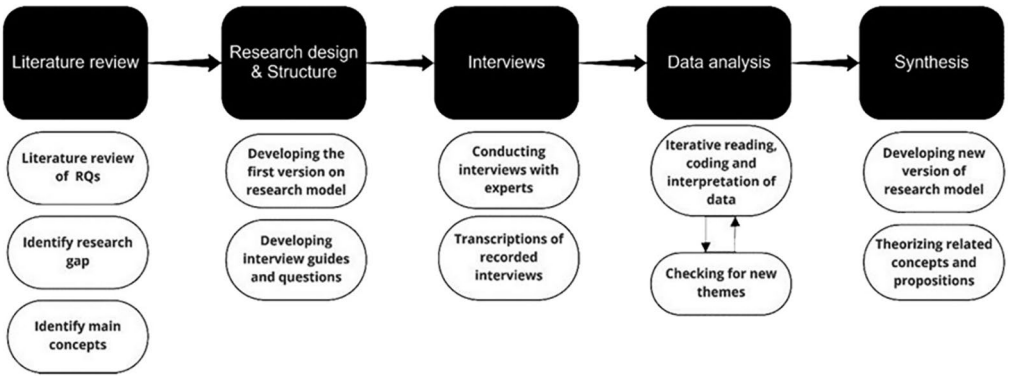

FIGURE 3.1 Research steps of the study.

et al., 2011; Mcafee and Brynjolfsson, 2012). As a result, researchers contend that the key to a CE transformation is closely tied to a digital transformation (Ingemarsdotter et al., 2020). This includes the effective use of DTs such as big data, artificial intelligence (AI), blockchain, the Internet of Things, and cloud computing, collectively known as Industry 4.0 technologies. Therefore, scholars concur that the adoption of CE is intimately connected with digitalization, as it can enable predictive analytics, tracking, and monitoring throughout an organization's product lifecycle (Bhatt et al., 2019; Ghoreishi and Happonen, 2020a).

Furthermore, recent advancements in AI are empowering machines to process vast unstructured data sets using complicated and adaptive algorithms to execute tasks that typically require human intelligence (Stone et al., 2018). AI and machine learning offer numerous benefits for the CE, including resource efficiency, ecosystem collaboration, recycling and resource recovery, reverse logistics, and closing the loops (Ghoreishi and Happonen, 2020a; Rajput and Singh, 2019; Sundui et al., 2021). This has prompted some to contemplate the generativity of AI, suggesting that the technology may not only provide a means of achieving cost and productivity benefits, but also represent a fundamental innovation to the tools we use to innovate.. However, these innovations also have broader potential negative impacts that start-ups must adapt to. Despite the growing prevalence of both mechanical and cognitive automation, there is limited literature on the intersection of start-ups and AI in CE, particularly on how start-ups utilize AI and machine learning technologies to accelerate CE. To bridge this gap, this study aims to answer the following question:

QR: What is the current implementation of AI in data-driven CBMs by start-ups?

To answer this question, this study employs thematic analysis of a series of semi-structured interviews to identify the key AI technologies implemented by start-ups in data-driven BMs and to explore how these BMs help born-circular start-ups to accelerate CE solutions. The rest of this work is as follows: first, the authors provide the background on the relationship between AI technologies and CE, followed by the theory of entrepreneurship in CE and capabilities of AI in BM innovations. Next, Section 3 describes the research methodology including the analysis of five semi-structured interviews with experts. Finally, the results and final discussions of the study are presented in Section 4.

2 Background

2.1 AI as an Enabler of CE

Digital tools can assist businesses in monitoring material movement, assessing circularity and its effects, identifying and seizing new commercial prospects, optimizing resource consumption, and depending on precise and reliable data exchange. Therefore, readily available data is the cornerstone of CE, enhancing internal procedures and profitability. Some companies have also introduced supplementary digital services to help their customers better manage or utilize their CE solution (Ahola and Tolonen, 2021). In the data value creation process, data is initially transformed into information, which is then merged with other sources and interpreted by humans to generate knowledge. This knowledge is further enriched with collective interpretation and experience to create wisdom (Luoma et al., 2021). Designing for circularity using data-driven insights can enhance the economic and environmental sustainability of products through efficient resource use. Such products, their components, and related processes can be designed and optimized using CE principles by applying predictive and prescriptive machine learning insights (Bressanelli et al., 2018). Historical and real-time data can forecast demand and manage inventory, reducing waste and promoting sustainable operations. AI is defined as a system's capability to act intelligently and expand its scope, accurately interpreting external data and using these lessons to achieve specific goals and activities through flexible adaptation (Kaplan, 2016). AI and machine learning can be used in various ways to offer and manage smart products, services, and experiences by sharing information for collaboration or creating optimal and sustainable value (Brynjolfsson and Mcafee, 2017). The primary advantage of AI techniques for CE is their ability to gather, process, and analyze large amounts of data quickly and in real-time from various sources (Mühlroth and Grottke, 2020). AI techniques can support the circularity of the entire value chain by predicting consumption and demand, enabling smart product design, and enhancing remanufacturing processes through remote monitoring (Ghoreishi and Happonen, 2020b). AI techniques can facilitate CE opportunities by promoting circular product design and development, optimizing infrastructure to ensure product flows, and implementing CBMs (Ellen MacArthur Foundation and Google, 2019). Table 3.1 presents how data creates value in CE and how AI techniques utilize data to boost circularity.

2.2 Role of Entrepreneurship in CE

The interplay between an individual and the contextual forces that hinder or enable an entrepreneurial individual has been difficult to translate to theoretical development in the field, as have the opportunities an entrepreneurial individual responds to. Venkataraman (York and Venkataraman, 2010) defines the field of entrepreneurship as "how opportunities to bring into existence 'future' goods and services are discovered, created, and exploited, by whom, and with what consequence". Even though two decades have passed since Shane and Venkataraman's (2000) article on establishing entrepreneurship as a separate research field, the topic of entrepreneurial opportunity is as relevant as ever, also in the emerging CE.

The construct of entrepreneurial opportunity has been manifested in research, arguing that entrepreneurship cannot occur without an accompanying opportunity no matter

TABLE 3.1 The type and value of data in CE, CBMs, and utilization of AI

Data value	*Type of data*	*Data-driven business models enabled by AI*	*Role of AI techniques*	*Reference*
Data for prolonging products' life	Data on customer's needs and demands enables optimization of product's design. Data on product condition and waste stream helps companies to provide services to support longer lifetime (e.g., maintenance service, reuse, refurbish, remanufacturing services).	Product-service systems	Cloud computing technologies enable digital platforms that can manage operational activities and services. Cloud technologies utilizing AI and machine learning can integrate and show data to the company for better decision-making on products/services.	(Ranta et al., 2021)
Data for operation optimization	Data transparency on each stage of product lifecycle increases efficiency in supply change management and optimization as well as better product quality. System operation and performance data, data from value chains.	Cloud-based enabled supply chain	AI and data analytics techniques enable visibility and outsourcing in price and revenue decisions through predictive capabilities. Digital platforms transfer real-time data that enables transparency throughout the entire supply chain.	(Ivanov et al., 2022)
Data for resource efficiency	Data on consumer's behavior and use of products increases resource optimization through collaborative consumption (sharing, exchanging, renting). Sharing data on shared assets and resources improves resource efficiency by reducing ownership of assets and products.	Sharing economy	AI enables predictive maintenance through analysis of real-time data transferred by Internet of Things–embedded sensors on products and assets. Digital platforms enable transferring of data between companies and various consumers, and enable tracking of consumer behavior in using products and assets.	(Centobelli et al., 2020)
Data for inventory management	Data on conditions of different parts of products improves quality of remanufacturing. Historical data on a product design, use, and return enhances product development, process development, and after-sales services. Data on material flow and returns improves response time to drive changes.	Digital remanufacturing business model	Cloud-based services support the development of distribution process planning in decentralized dynamic remanufacturing environment through machine learning algorithms. Smart robots enable intelligent sensing remanufacturing through real-time data adaptation.	

Abbreviations: AI, artificial intelligence; CBMs, circular business models; CE, circular economy.

how much motivation or expertise the entrepreneur possesses. This research adopts this view and assumes an individual–opportunity nexus approach as the basis for research within the field of entrepreneurship as detailed by Eckhardt and Shane (2003).

Entrepreneurial opportunities exist when new goods, services, raw materials, and organizing methods can be utilized and sold for more than the cost of production and are discovered when someone realizes that the resource in question is not put to its "best use". The entrepreneurial opportunity construct concerns the existence, discovery, and exploitation of opportunities (Eckhardt and Shane, 2003). The quality and value of such opportunities vary greatly and thus understanding them is imperative to explaining entrepreneurship.

Scientific research on CE has previously been centered around engineering, natural science, and technical solutions, while research on CBMs, circular business strategies, and management supporting CE has been diminutive (de Sousa Jabbour et al., 2018; Stall et al., 2018). Further research on CE is needed to convince businesses and governments that CE is a feasible alternative to the current predominantly linear economy.

Both internal and external factors that are pushing the CE agenda include stricter regulations, changes in consumer behavior, and new technologies available in the market. Also, renewed commitment from consumers to consume more responsibly is a global trend that shows through a willingness to pay more for eco-friendly and recyclable products, and a desire for plastic-free purchases. These examples pose significant changes to the business environment and are therefore considered external enablers (Davidsson et al., 2020), pushing the CE of which we focus on the new aspects of aspect in the form of AI. Internal motivations to redesign a firm's BMs are to boost resource efficiency, and close the loops of energy and material flow (Geissdoerfer et al., 2020) as cost-reduction measures. The CE is quickly gaining traction as a method for enhancing and reimagining economies. It addresses increasing resource-related issues, creates employment opportunities, stimulates innovation, and yields significant environmental benefits (European Commission, 2020). This approach not only promotes sustainability but also has the potential to drive economic growth. It's a win–win situation for both the environment and the economy.

Recent studies identifies that "entrepreneurship, innovation, and socio-economic development" increases circularity significantly. (Kostakis and Tsagarakis, 2022). Kostakis and Tsagarakis (2022), realize that the above elements have positive impacts on circularity. According to their findings, 1% increase in entrepreneurship in Europe increases circularity rate by 0.19% whereas 1% increase of research and development which leads to innovative solutions enhances circularity rate by 0.65% on average. On the other hand, 1% increase of economic growth increases circularity rate annually by 0.73%. Therefore, by providing more opportunities for entrepreneurship in Europe, innovation level will rise and leads to an advancement in socio-economic matters which all in return leads to faster progress in circularity. However, there is limited literature on how entrepreneurs adapt DTs such as AI to provide innovative solutions for circularity. Therefore, this study aims to fill this gap by analyzing cases that implement innovative circular solutions and examining their current situation in adaptation of AI. (Kostakis and Tsagarakis, 2022). Entrepreneurially inclined individuals drive collaborations by sharing a vision, enthusiasm, and importantly, a convincing proposition for a CE. Moreover, collaboration is pursued at an early stage to co-develop the problem and solution space

and to integrate diverse knowledge from across the value network, thereby mitigating increased complexity (Brown et al., 2019). Additionally, sustainable entrepreneurship can advocate for changes in institutional structures, enabling the exploitation of sustainable opportunities, enhancing the competitiveness of sustainable behaviors, and fostering new entrepreneurial mindsets. This approach not only promotes sustainability but also encourages innovation and entrepreneurial spirit.

3 Research Methodology

3.1 Research Design

A multiple case study analysis was conducted of Finnish small companies and start-ups specifically providing CE solutions. Due to the nascent stage of research on the topic of CE, a case study approach is a suitable methodology for empirical investigation to understand the phenomenon as well as to help build theory at such an early stage.

Case studies seek to understand the dynamics of a single setting (Eisenhardt, 1989) or to investigate a contemporary phenomenon (Yin, 2014); therefore, a qualitative multiple case study research strategy is the methodological framework best suited for this exploratory research into the novel and innovative business ecosystems of digital start-ups enhancing or accelerating a CE. The case study research strategy, furthermore, has distinct advantages when researching how a contemporary set of events take form, particularly when the researchers have no control over the events. External validity is sought through the use of replication logic in the research design and to choose which companies to include in the research.

3.2 Data Collection

Each of the five case companies were carefully chosen according to our three core criteria for inclusion: (1) start-up or small size of company, (2) specifically providing solutions for the transition to a CE, and (3) availability of CEO or founder for online interviews due to COVID-19 restrictions on travel and physical meetings. The interviews were conducted during February, March, and April 2021. The data is centered around in-depth semi-structured interviews with either founders or CEOs of each of the case companies, although several types of data are being collected to strengthen the construct validity. Therefore, the data includes interviews, press releases and other online news, and each company's website, although the documents available differ between the case companies due to their small size and relatively young age in many cases. The interviews were conducted online via videocalls and were all recorded and immediately transcribed to ensure accuracy during the data analysis phase. The majority of the case companies were identified through an industry expert after which three additional companies were added after a comprehensive internet search. The cases are carefully chosen within this single digital CE ecosystem setting. The selection criteria for inclusion in the research were (1) explicit purpose to create a CE-enhancing solution, (2) inability to have created the same CE business solution without the use of DTs, (3) from Finland, and (4) categorized as a "small" business, rather than medium or large.

TABLE 3.2 Case company details including circular objectives and BMs

Company name	*Year established*	*Business area*	*CE objectives*	*Circular business model*
Biocode	2017	The most reliable tool for climate smart food that helps conscious companies to identify tangible ways to decarbonize food production.	Reducing carbon footprints of food products Reducing the climate impact of the food products to different stakeholders Reducing food waste within different phases of value chain	Online services Software-as-a-service Climate smart product tags Online product profiles
Emmy	2015	An online Nordic marketplace for pre-owned premium clothing.	Reducing emissions in textile and fashion industry Reducing waste Support the European Commission's Zero Carbon Emission strategy Reducing the raw material extraction	Resell clothes Resale as a service platform
Kauppaval mennus	2014	A company that studies and trains processes and software in retail according to lean management principles.	Reducing food waste Increasing efficiency of food shortages and excess storage	Software-as-a-service
Biocode	2017	The most reliable tool for climate smart food that helps conscious companies to identify tangible ways to decarbonize food production.	Reducing carbon footprints of food products Reducing the climate impact of the food products to different stakeholders Reducing food waste within different phases of value chain	Online services Software-as-a-service Climate smart product tags Online product profiles
Emmy	2015	An online Nordic marketplace for pre-owned premium clothing.	Reducing emissions in textile and fashion industry Reducing waste Support the European Commission's Zero Carbon Emission strategy Reducing the raw material extraction	Resell clothes Resale as a service platform

(*Continued*)

TABLE 3.2 (Continued)

Company name	*Year established*	*Business area*	*CE objectives*	*Circular business model*
Kauppaval mennus	2014	A company that studies and trains processes and software in retail according to lean management principles.	Reducing food waste Increasing efficiency of food shortages and excess storage	Software-as-a-service
RePack	2011	A packaging service that enables the return and reuse of delivery packaging for online retailers and their users.	Reducing the waste from packaging Reducing raw material extraction	Package reuse model
Yield Systems	2018	An AI company with science background that develops machine learning solutions for agri-food value chain enhancement and video intelligence.	Reducing CO_2 emission	Data collection and analytic services

Abbreviation: BMs, business models.

All interviews were conducted in English and data reliability has been addressed through the use of a simple case study protocol and a common database of case material accessible to all authors.

3.3 Data Analysis

The data analysis will follow an abductively developed model currently being developed. The model is developed specifically for this research based on the data gathered and theoretical components from relevant literature. For the data analysis, the Nvivo12 software was used as a tool to code, analyze, and compare the data. To address internal validity, two authors independently of each other will code all interviews and then compare and discuss where dissimilarities are found until agreement is reached. The analysis is planned to occur in two phases due to the two levels of analysis. A within-case analysis (Eisenhardt, 1989) of the unit of analysis is the first stage in which each company will be analyzed separately. The second stage of analysis will be a cross-case analysis to compare and contrast the findings to bring the level of analysis up the meso-level where patterns and trends can be identified. Therefore, the unit of analysis is the DTs that the start-up companies utilize in accelerating a CE and the level of analysis is the digital circular start-up ecosystem.

4 Results and Discussions

In CE, entrepreneurship is viewed as the inventive process of discovering and capitalizing on new business opportunities to boost circularity (Veleva and Bodkin, 2018). By creating innovative BMs, entrepreneurs can contribute to circular solutions through new products and services, which pose more challenges and risks to established firms (York and Venkataraman, 2010). Meanwhile, the shift towards CE is rapidly progressing with

TABLE 3.3 DTs and CE strategies of case companies

DTs utilized	*CE solutions*
Cloud-based, APIs, user-interfaces, databases, database integrations.	Lifecycle assessment of food products to reduce the carbon footprint and developing more value to the value chain of the food products.
Big data, software development (coding)	Reducing food waste by forecasting the precise amount of food shops need to order and preventing extra storage and food waste.
Digital platform	Reducing waste in packaging by durable and reusable packages. Reduce natural resource usage by using recycled polypropylene as raw material and will be upcycled in case the package breaks.
APIs, headless architecture, opensource website.	Connecting individuals to designers and organizations in local areas to share upcycled/recycled/sustainably produced products and services.
Algorithms, cloud infrastructure, AI, machine learning.	Reducing CO_2 by accelerating the field and breeding better plants that absorb CO_2.

Abbreviations: APIs, application programming interfaces; DTs, digital technologies; RFID, radio frequency identification.

TABLE 3.4 Type of data, DTs, and utilization of AI in circular solutions of cases

Type of data	*DTs*	*Utilization of AI technologies*
Data on different parts of food products' lifecycle	Azure cloud-based technology Modern interface coding	Not yet Huge potential for machine learning algorithms and AI in company's product roadmap
Data on individual land-based farming such as data on the type of soil, nutrients, fertilizers, and fuel	Conventional software development technologies Database integrations between different operators and APIs	Requires having bigger data pools
Data on lifecycle and durability of textile products Data on resale price Data on quality of the product Data on material Process data	Digital platform Machine learning for databases AI for pricing automation AI for matching products Google analytics Cloud-based platforms RFID tags for products and packs	Yes
Data on lifecycle of products	Big data	Not yet
Data on waste	Conventional software development technologies	High potential for AI
Data on sales		Potential of QR codes that hold expiry dates
Data on lifecycle of packages	Digital platforms	No
Data on logistic processes	In-house-developed system Conventional software	Potential of automated inspection by machine vision Potential of utilizing sensors to track real-time data on logistics
Digital phenotypical data on plants in various plots	AI-based analytics Mobile apps	Yes AI
Data on conditions, disease symptoms, and number of grains in plots Data on agri-food value chain	Algorithms	Machine vision Deep learning

the expansion of the DT field and its capabilities related to circularity. However, research in the area of CE and entrepreneurship remains abstract, with only a few studies focusing on the applications of DTs in circular entrepreneurship (Suchek et al., 2022).

The findings of this study revealed that all start-ups highlighted the essential role of data in their solutions, and that data utilization enables their products and services to align with CE objectives. Despite the use of DTs in all their solutions, only two companies utilize AI technologies, such as machine learning and analytics. The other three cases mentioned that they still use traditional software solutions but recognize the potential of AI in many solutions. This is attributed to a shortage of skills and the high cost of modern technologies for young ventures with low revenue. This highlights the need for more accessible and affordable AI solutions to further drive innovation in the CE space.

As presented in Table 3.4, data plays essential role in tracking lifecycle of the products. Moreover, the interviewees described the enablers of their business factors such as

global megatrend of climate change, the pressure towards producers for their impacts of activities for supplying raw materials on climate and increasing consumer awareness about climate change. For example, the enabler of the Emmy start-up has been the global warming and high emission of fashion industry, challenges and complexity in recycling of textiles, difficulty to access flea markets, and the need for a safe, risk-free seller–customer marketplace in which products are curated. Hence, digital platforms can be considered as a suitable and practical solution in enabling CE and AI can play crucial role in this case. The value of digitalization of the processes is evident for all the companies especially since the conventional data collection is costly, not efficient, and not accurate. There is still a lack of direct integration of data to the systems while data is exchanged mostly through google sheet. On the other hand, EU regulations are forcing companies to look for more innovative environmental solutions that are linked to data and require utilization of DTs. In this regard, digitalization and automation of supply chain can help in accessibility of data through the entire value chain, which is currently lacking.

TABLE 3.5 Entrepreneurial ecosystem actors of circular start-ups studied in this chapter

Policies	Paris Climate Agreement
	EU's climate goals
	National climate goals
	EU's policies on environment
Competitors	Consultancies and research institutes
	Public assistance
	Traditional farming system
Finance	Spin-off by two established companies
	Innovation funding agencies
	Growth funding sources from Finland or the EU
	Private equity markets
	100% financed by the owner
	Venture capital funding
	Public funding (business Finland)
	Horizon2020 funding
Culture	Mission-driven organization
	Lean community, especially Lean-yhdistys
	Progressive culture due to the growth of company
	Data sharing culture from plant breeders
Support	Collaboration with marketing agencies in terms of branding, marketing, and communication activities
	Collaboration with research organizations
	Partnering with VTT, LUKE, and Finnish metrological institute
	Stores as customers
	IT infrastructures
	Non-governmental institutions like the Ellen MacArthur Foundation
	Different kinds of competitions
	NGOs that are organized around the circular economy
	Research institutes
	Governmental research institutes like Sitra
	Cloud infrastructure
	Policy agencies
Crowdsourcing	Lot of potentials but not yet fully utilized

(*Continued*)

TABLE 3.5 (Continued)

Human Capital	The core of the company is a skilled and knowledgeable team
	Collaboration with educational institutes, universities, Aalto University, and Haga Helia
	Software developers
	IT experts are the core
	Industrial design
	Logistics
	Graduate students from education institution
Market	Valio Carbo® Farm calculator for the carbon footprint assessment of raw milk
	HKScan a tool to assess the carbon footprints of beef, pork, and poultry
	Assessed carbon footprint of Finnish bakery Vaasan's selected bread brands
	Assessed carbon footprint of oat flakes for Kinnusen Mylly
	Assessed carbon footprint of fava bean brand Härkis and Beanit for Verso Foods
	Misunderstanding of the offered service is the biggest challenge
	Early customers, Finalyson, New fashion webshops focused on sustainability brands
	Early customers, media like Seed World group, testing institute such as LUKE in Finland, industrial dynamics
Partnerships	Partnership with digital marketing company
	Partners in logistics
	Partnership with Shopify for customer interface

Furthermore, companies explained the role of different actors in their ecosystems and how the entire entrepreneurial ecosystem enables them to achieve their CE goals. For example, environmental policy regulations play significant roles in the birth and survival of the business. Ecosystems were considered important factors for the circularity of the company since the assessment of product circularity and sustainability in the entire value chain is essential. Table 3.5 presents different actors of the case companies' ecosystem in Finland within this study.

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