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DECODING THE DIGITALIZATION-LED CIRCULAR ECONOMY IN FINLAND

Trang Nguyen Tinh Vu

International Business
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Supervisor: Pasi Rikkonen
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School of Business
Bachelor´s Program in International Business
Mikkeli Campus

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SCHOOL OF BUSINESS
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ABSTRACT OF
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Author: Trang Nguyen Tinh Vu

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Objectives

The objectives of this study are to examine how perception affects the approach taken by Finnish companies in implementing circular economy (CE) practices, evaluate the effectiveness of Finland's policy approach for CE, and investigate the role of digitalization in shaping the practices of leading CE companies.

Summary

Environmental problems pose significant threats globally, and CE is a promising solution. Finland is committed to becoming a leader in CE implementation. This study aims to explore the adoption and implementation of CE practices among private enterprises in Finland, examining the role of digitalization and government policy approaches in promoting and scaling up CE.

Conclusion

CE implementation among private enterprises is context-dependent and focuses on practical applications. The Finnish government uses a combination of policies to achieve CE goals, but the effectiveness is uncertain. Digitalization can be crucial for particularly start-ups whose business models also align with CE principles.

Key words: business, circular economy, digitalization, Finland

Language: English

Grade:

GLOSSARY

Circular Economy (CE)

A systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution, and is based on three principles, driven by design: (1) Eliminate waste and pollution, (2) Circulate products and materials (at their highest value), and (3) Regenarate nature (EMF, n.d.).

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended (European Parliament, 2023).

Digitalization

Digitalization is a phenomenon of integrating digital technologies and ICT solutions into businesses and society; it is a conversion from the analog world into one of digital communications in its multiple applications across the many domains of our society (Broadband Commission for Sustainable Development, n.d.).

Digital Technologies

Electronic tools, automatic systems, and technological devices that generate, process and store information, and they are widely seen to be both disrupting and reshaping business practices and models and changing the everyday world in which we live (Wynn & Jones, 2022).

Sustainable Development (SD)

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

1 INTRODUCTION

1.1 Background

Environmental problems have become increasingly alarming in recent years, with the devastating impacts of climate change, resource depletion, and pollution posing significant threats to ecosystems, economies, and societies worldwide (IPCC, 2014; UNEP, 2019). In response to these urgent challenges, the concept of the Circular Economy (CE) has emerged as a promising solution, offering a sustainable alternative to the traditional linear economic model by promoting resource efficiency, waste reduction, and closed-loop systems (EMF, 2012; Korhonen et al., 2018).

Finland has demonstrated its commitment to becoming a leader in implementing CE, with ambitious national strategies and policy initiatives aimed at fostering a transition towards a circular and sustainable economy (Finnish Government, 2019; Sitra, 2019). This determination is further supported by the country's strong innovation ecosystem, world-class education system, and renowned expertise in digital technologies (OECD, 2018).

The systematic changes that CE aims to bring about can be greatly facilitated by the integration of digital technologies, as these tools can enhance resource efficiency, enable new business models, and foster collaboration among various stakeholders in the CE ecosystem (Antikainen & Valkokari, 2016; Lieder & Rashid, 2016). By leveraging the potential of digitalization, Finland can accelerate its transition towards a sustainable and CE, further cementing its status as a global frontrunner in CE implementation.

In light of these developments, this research aims to explore the CE landscape in Finland, particularly through the perspective of private enterprises. By examining the factors influencing the adoption and implementation of CE practices, especially digitalization and policy approach by the Finnish government, this study will contribute valuable insights into promoting and scaling up CE in the Finnish context.

1.2 Research Questions

1. In what ways does the perception of the CE influence the approach that Finnish businesses take in implementing CE practices?
2. How effective is Finland's policy approach in promoting a collaborative CE ecosystem?
3. How does digitalization assist the CE companies in Finland?

1.3 Research Objectives

The research aims to explores the CE landscape in Finland from the perspective of (private) enterprises. The specific objectives are to examine how perception affects the approach taken by Finnish companies in implementing CE practices, evaluate the effectiveness of Finland's policy approach in promoting a collaborative CE ecosystem, and investigate the role of digitalization in shaping the practices of leading CE companies. By addressing these questions, this study could contribute to the understanding of the factors influencing the CE development, thereby providing insights into how CE can be promoted and scaled up in the Finnish context.

2 LITERATURE REVIEW

The purpose of this literature review is to establish a context for the development of a digitalization-led CE in Finland. The structure of the literature review can be divided into seven sections. The first two sections examine the evolution, theoretical formation, and implementation of CE. Sections 3 covers the situation in Finland. Section 4 attempts to draw a connection between CE and digitalization. Section 5 explores the level of and orientation for digitalization in Finland. Section 6 briefly discusses the Multi-Level Perspective (MLP) on Socio-technical Transitions (Geels, 2002), which provides the theoretical basis for the conceptual framework in section 7.

2.1 Conceptualizing Circular Economy

The following section provides an in-depth discussion and analysis of the conceptualization of the Circular Economy (CE), beginning with the historical development of the concept. Subsequently, the foundational aspects and the core

principles of the CE are explored, along with related concepts such as the Bioeconomy and Sustainable Development (SD). Finally, this section concludes by highlighting key considerations regarding the definition of CE.

2.1.1 Evolution Timeline of Circular Economy

Alcadel-Calonge et al. (2022) divided the thirteen-year development of CE from 2008 to 2020 into four major phases. Figure 1 includes the first three periods: emergence (2008 – 2011), early stages (2012 – 2015), take-off (2016 – 2019), in addition to a theoretical foundation which will be further discussed in the subsection 1.1.2.

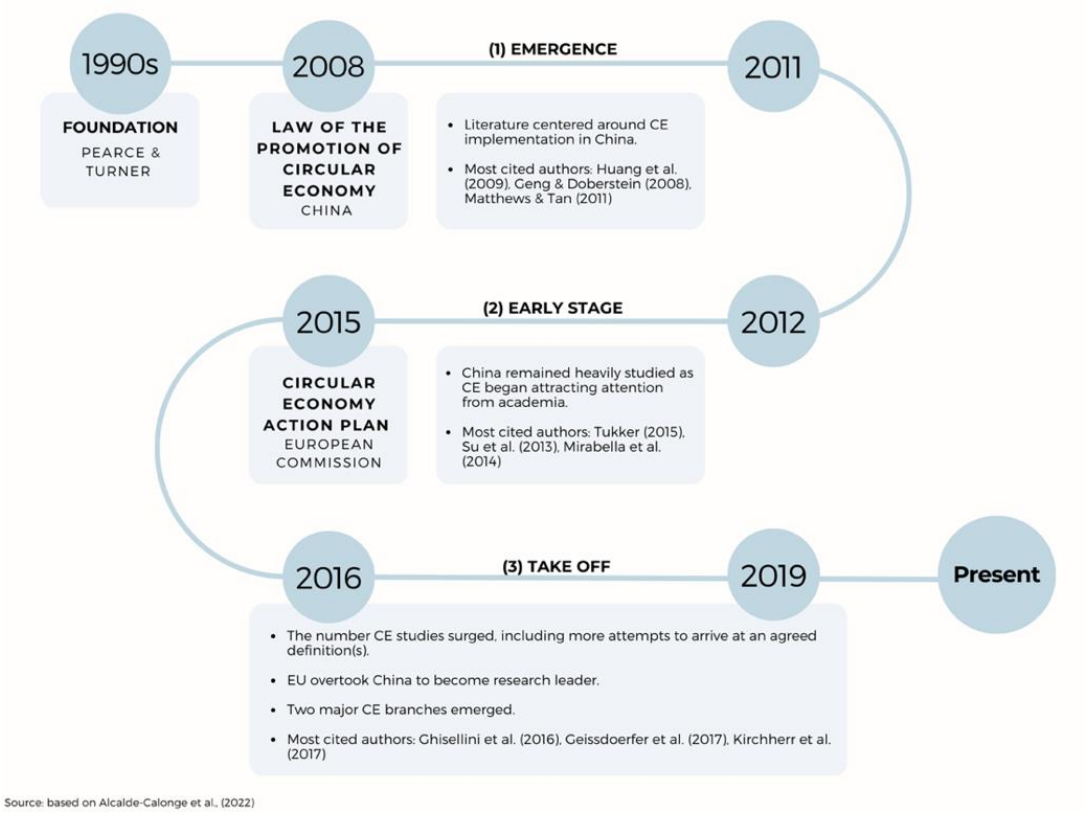

Figure 1: Evolution of Circular Economy (based on Alcade-Colonge et al., 2022)

Regarding the first stage, China is reported to be the earliest adopter and promoter of the concept, with Bartl (2020) even went as far as claiming that CE is a merely ‘a Chinese invention’. This could be explained by the country’s solid efforts in establishing a domestic CE, including the enactment of the Circular Economy Promotion Law of the People's

Republic of China in 2008. According to the law, CE was defined as ‘a generic term for the reducing, reusing and recycling activities conducted in the process of production, circulation and consumption’ (Pesce et al., 2020). This Chinese interpretation, however, seems to be more limited than theories later proposed by the Ellen MacArthur Foundation (EMF), another active and influential accelerator of CE. The EMF mentioned not only ‘reducing, reusing, and recycling activities’ but also ‘product refurbishment’, ‘component remanufacturing’, ‘cascading of components and materials’, and ‘energy recovery’ to illustrate the ‘regenerative’ and ‘restorative’ nature of CE (EMF, 2013).

The 2012 – 2015 period witnessed a growing interest in CE by researchers worldwide, even though a significant portion of research was still dedicated to China. Moreover, in December 2015, the European Union (EU) approved its (first) Circular Economy Action Plan, marking the organization’s first critical step towards a CE.

Undoubtedly, the ‘take-off’ stage was the most prolific period in terms of CE literature up to that point. The most cited authors (Ghisellini et al., 2016; Geissdoerfer et al., 2017; Kirchher et al., 2017) in this time were mainly concerned with synthesizing the abundant, yet unsystematic, information surrounding CE for an agreed understanding.

2.1.2 Foundational Premises

Several scholars (Ghisellini et al., 2016; Alcalde-Calonge et al., 2022) agreed that CE was first coined by economists Pearce and Turner, as the earliest mentioning of CE traced back to their work ‘Economics of Natural Resources and the Environment’ (1990). The two scholars were inspired by and extended the ideas put forward in the essay ‘The economics of the coming spaceship Earth’ (Boulding, 1966). Pearce and Turner then identified three key roles of the environment as follow: (1) ‘resource supplier’, (2) ‘waste sink’, and (3) ‘direct source of utility’. Hence, CE is described as a ‘close’ and ‘circular’, as opposed to the traditional ‘open’ and ‘linear’ system which does not take the environment into account (Pearce & Turner, 1990). The transition to CE is thus argued to be critical as the linear, or the ‘take, make, and dispose’ (Ness, 2008), model could cause catastrophic results to mankind. This is due to the unsustainable nature of the linear

system (Diaz-Garcia et al., 2020), where resources are extracted to produce goods, and used goods or materials become waste and released into the environment. While the environment has its ability to handle both the waste created by itself and mankind (Pearce & Turner, 1990), the amounts of resources exploited and waste emitted by humans have exceeded Earth's regenerative capacity (Earth Overshoot Day, n.d.), jeopardizing the planet's function as a provider of resource and assimilator of waste.

These ideas of Pearce and Tuner, however, were not strictly unique when compared to earlier thinking, particularly Industrial Ecology (IE) (Saavedra et al., 2018). Initially introduced in the late 1908s (Erkman, 1997), IE also aims at a more holistic framework and sustainable process to treat industrial waste (Frosch & Gallopoulus, 1989; Lowe & Evans, 1995). In short, it is reasonable to conclude that CE, despite being a new field, has its bedrock derived from a number of predecessor schools of thought (Ghisellini et al., 2016; Reike et al., 2018).

2.1.3 The Essence of Circular Economy

During the embryonic stage, CE was most associated with the 3Rs framework: Reduce, Reuse, Recycle (Kirchherr et al., 2017). This can be partly attributed to the prevailing popularity of the 3Rs as a waste management tool, especially in Asia. For example, it was featured in the Circular Economy Promotion Law of the People's Republic of China (PRC, 2008) as well as promotional campaigns for waste management in neighboring countries such as Korea, Japan, or Vietnam (Sakai et al., 2011). Meanwhile, the 4Rs framework, which added a fourth R, Recover, after Recycle, was a crucial part of the EU Waste Framework Directive (EC, 2008) and has been selected for multiple CE research (Kirchherr et al., 2017). With growing attention drawn to CE, more Rs have been added to the framework to illustrate the variation in the interpretation and application of CE by different scholars and practitioners. Reike et al. (2018) compiled a total of 69 R-imperatives, ranging from 3Rs to 10Rs, and compared them in terms of frequency to be featured in scholarly sources (Figure 2).

#Rs	Count (Total/#R)	WM	RL/CLSC	CDCP	IE	CE2010+	Author Contribution
3R's	13 6 Green 2 Yellow 5 Orange	4	3	2	0	4	Yoshida et al. 2007; Amelia et al. 2009*; Xing & Luong 2009; Wang & Hsu 2010; Geng et al. 2012; Hassini et al. 2012; Jones et al. 2013*; Su et al. 2013; Bakker et al. 2014*; Ghisellini et al. 2014; Lieder & Rashid 2016*; Xin 2014; Diener & Tillmann 2015*
4R's	14 9 Green 4 Yellow 1 Orange	2	6	0	6	0	Greadel & Allenby 1995*; Ayres & Ayres 1996*; Cohen-Rosenthal & Musnikow 2003*; Guide et al. 2003*; Kazazian 2003*; Blackburn et al. 2004*; King et al. 2006*; Defee et al. 2009; Graedel et al. 2011*; Kazerooni Sadi et al. 2011; Hazen et al. 2012*; Loomba & Nakkashimi 2012; Rahman & Subramanian 2012; Stahel & Clift 2016*
5R's	19 13 Green 3 Yellow 3 Orange	6	6	3	4	0	Fleischmann et al. 1997*; Price & Joseph 2000; Tyler Miller & Spoolman 2002; Roine & Brattebo 2003*; Stahel 2003*;Fernández & Kekäle 2005; Gerrard & Kandlikar 2007*; Mitra 2007; Gehin et al. 2008; Rahman et al. 2009; Rusjanto 2010; Stahel 2010*; Li 2011; Yan & Wu 2011; Hultman & Corvellec 2012; Romero & Molina 2013*; Worrell & Reuter 2014*; Agrawal et al. 2015; Sinha et al. 2016*
6R's	12 5 Green 5 Yellow 2 Orange	1	7	4	0	0	Peng et al. 1997; Jawahir et al. 2006; Srivastava 2008*; Badurdeen et al. 2009; Jayal et al. 2010; Ingarao et al. 2011; Kuik et al. 2011; García Rodríguez et al 2013; Nagalingam et al. 2013; Yan & Feng 2014; Go et al. 2015; Govindan et al. 2015
7R's	4 3 Green 1 Yellow	0	2	0	2	0	De Brito & Dekker 2003*; Francis 2003; Liu et al. 2016*; Fercoq et al. 2016
8R's	2 1 Green 1 Orange	0	1	0	0	1	Thierry et al. 1995; Bilitewski 2012*
9R's	3 3 Green	0	3	0	0	0	Silva et al. 2013; Sihvonen & Ritola 2015; van Buren et al. 2016
10R's	2 1 Green 1 Orange	1	0	1	0	0	Allwood et al. 2011; Den Hollander & Bakker 2012
Total	69	14	28	10	12	5	

Figure 2: Representation of R-imperatives for circular economy in academic literature (Reike et al., 2018)

The acronyms on the header row stand for 'Waste Management and Environmental Sciences (WM), Reverse Logistics and Close-Loop Supply Chain Management (RC/CLSC), Product Design and Cleaner Production (CDCP), Industrial Ecology (IE), and Circular Economy 2010+ (CE2010+)' respectively. Thus, the figure 1 suggests that different areas of CE tend to prefer distinct Rs Framework. Moreover, the 3Rs framework, despite its simplicity, dominates CE literature compared to younger and more multi-dimensional counterparts (Reike et al., 2018). This observation is in line with earlier research (Kirchherr et al., 2017). Nevertheless, while certain variations of the Rs frameworks might overshadow the others in terms of prevalence, there has not been a general agreement on which particular Rs framework captures the essence of CE. Such absence of uniformity poses an enormous challenge for CE adopters from diverse backgrounds, thus obstructing the international collaboration among nations utilizing different frameworks.

2.1.4 Circular Economy, Bioeconomy, and Sustainable Development

One concept that is often used interchangably with CE is bioeconomy (Tan & Lamers, 2021). CE, Bioeconomy, and SD are three interconnected concepts that have gained increasing attention in recent years, as the global community seeks to mitigate the negative environmental and social impacts of traditional linear economic models. Overall, CE aims to minimize waste, extend product lifecycles, and optimize resource utilization, thereby reducing the pressure on natural resources and minimizes environmental degradation caused by waste accumulation and resource extraction (Ghisellini et al., 2016). Meanwhile, bioeconomy focuses on utilizing renewable biological resources, such as plants, microorganisms, and waste, to produce materials, chemicals, and energy that can replace their fossil-based counterparts. This transition to biobased products helps reduce greenhouse gas emissions and supports sustainable resource management (McCormick & Kautto, 2013). When biobased materials are incorporated into circular systems, the circular economy can benefit from the renewable and biodegradable nature of these resources, thus minimizing environmental impacts. Conversely, the circular economy principles can be applied to the bioeconomy by promoting the efficient use and recycling of biobased resources, maximizing their value, and minimizing waste (Geissdoerfer et al., 2017). Both the circular economy and bioeconomy contribute to SD, which encompasses economic growth, social well-being, and environmental protection. The adoption of circular economy principles and the transition to a bioeconomy can lead to new job opportunities, increased resource efficiency, and reduced environmental impacts, all of which support the United Nations' Sustainable Development Goals (United Nations, 2015). In summary, CE and bioeconomy are interconnected concepts that work synergistically to support SD. By combining circular strategies with the use of renewable biological resources, societies can drive economic growth while reducing their environmental footprint and promoting social well-being, ultimately contributing to a more sustainable and resilient world.

2.1.5 Conclusion about the Definition of Circular Economy

According to Korhonen et al. (2018), CE has become an ‘essentially contested concept’ in which the objectives and methods are agreed upon, but there is no consensus on its

definition. The conceptualization of CE remains an ongoing process, with new principles introduced to capture more nuances surrounding the economic model. Although there have been disagreements about the definition of CE, there appears to be a growing consensus on its key elements, such as the use of phrases like ‘circular’ and ‘closed’ to describe the economic model, and the inclusion of the Rs frameworks at various levels of the economy.

2.2 Implementation of Circular Economy

The section below examines the implementation of CE from three major aspects: indicators, drivers, and barriers.

2.2.1 Circular Economy Indicators

Among the literature attempting to provide a broad view of CE indicators, Pascale et al. (2021) presented and analyzed 61 indicators invented and used in measuring CE results. Despite the high number of indicators gathered, a lot of them fail to include all the three pillars of sustainability and ‘lack a structured and standardized methodologies’ (Pascale et al., 2021). Furthermore, most of the indicators seem to be waste-centric (Moraga et al., 2019). This could be explained as data for waste is more reliable and readily available (EESC, 2018). Additionally, countries or companies might employ different CE to suit their CE strategy as well as the database available to them.

2.2.2 Enablers of Circular Economy

This section outlines the five major enablers of CE, namely (1) policy and regulation, (2) collaboration and partnerships, (3) education and awareness, (4) circular economy business models (CBMs), and (5) digitalization. Firstly, government policies and regulations can create a supportive environment for businesses to adopt circular economy practices. Policies may include waste reduction targets, landfill taxes, extended producer responsibility, eco-design standards, and incentives for using recycled materials. Such policies can make it economically viable for businesses to invest in circular economy initiatives. Secondly, establishing partnerships and collaborations among businesses, government agencies, research institutions, and other stakeholders

can facilitate the sharing of knowledge, resources, and best practices. This can help businesses overcome the barriers they face in implementing circular economy practices and can also create new opportunities for innovation and value creation (Tukker, 2015). Thirdly, raising awareness about the circular economy among businesses, consumers, and policymakers can lead to increased demand for sustainable products and services. Education and awareness campaigns can emphasize the environmental and economic benefits of circular economy practices, showcasing successful case studies and highlighting the role that individuals and organizations can play in driving change (Kirchher et al., 2017). Alternatively, as CE requires systematic changes, companies are expected to undergo profound transformation both in terms of business and operating models (Ludeke-Freund et al., 2018). As a result, a number of circular economy business models (CBMs) have emerged, although the terminologies related to these principles are unsystematic and fragmented. Among the proposed CBMs, some attracted more attention and, consequently, were more frequently used than the others. Woldeyes et al. (2022) pinpointed the frameworks by Accenture et al. (2014), EMF (2015), and Bocken et al. (2016) to be the most well-known CBMs. Finally, digitalization has emerged as a facilitator of CE (Antikainen et al., 2018). The relationship between digitalization and CE is further discussed in section 2.4.

2.2.3 Barriers to Circular Economy

Without financial incentives, businesses might be reluctant to invest in circular economy initiatives, as they may perceive these practices as costly and risky. Governments can introduce policies to incentivize businesses, such as tax breaks, subsidies, and grants for implementing circular economy practices (Rizos et al., 2016). Additionally, businesses can explore new business models that generate revenue from circular economy practices, such as product-as-a-service models. Secondly, some industries might face technical difficulties when adopting circular economy practices. As pointed out by Lieder and Rashid (2016), these challenges can include a lack of suitable recycling technologies, insufficient infrastructure for managing waste and resources, and difficulties in disassembling products for reuse or recycling. Investing in research and development, as well as collaborating with other organizations, can help businesses overcome these

challenges. In addition, global supply chains can be complex and opaque, making it difficult for organizations to trace and manage resources effectively. This can hinder the implementation of circular economy practices, as businesses might struggle to recover and reuse materials from their products (Genovese et al., 2017). To overcome this barrier, businesses can invest in supply chain transparency initiatives, collaborate with suppliers, and adopt digital technologies to track materials and products throughout their lifecycle. Finally, according to Hobson & Lynch (2016), resistance to change, lack of awareness, and entrenched linear economy mindsets can impede the transition to a circular economy. Overcoming these barriers requires a shift in societal values, consumer behaviors, and business practices. This can be achieved through education, awareness campaigns, and showcasing successful circular economy case studies that demonstrate the benefits of adopting such practices.

2.3 Circular Economy in Finland

The section presents an overview of CE development in Finland, highlighting the objectives and initiatives by the Finnish government, in relation with the current situation of the country.

2.3.1 Objectives

As an EU member state and an eco-friendly culture, Finland sets a highly ambitious targets for CE development. According to the Government Resolution on the Strategic Programme for Circular Economy, Finland aspires to attain a ‘carbon-neutral CE’ and ‘double the CE rate of material by 2035’. In addition, the ‘sharing economy will be a normal part of daily life’, with the use of ‘non-renewable resources diminishing’ and ‘sustainable use of renewable resources’ increasing. The transformation to a fully CE will boost economic growth, give birth to ‘new innovations’, and secure an ‘export advantage’ for Finland (Ministry of the Environment, 2021).

2.3.2 Policy Approach

The ambitious targets outlined by Finnish government require a plethora of policies on both international and national scales and through the cooperation of actors at all levels.

As an EU member state, Finland cooperates with other EU member states to implement the actions included in the EU Circular Action Plan and EU Green Deal. Moreover, Finland is also a part of the Nordic Working Group for Circular Economy (NCE), one among the seven under the leadership of the Nordic Council of Ministers (Nordic Co-operation, n.d.). Another program worth mentioning is Nordic Circular Hotspot (NCH), cohosted by the Nordics and Netherlands (NCH, n.d.).

In terms of domestic development, the government has introduced a wide range of measures. Firstly, Finland developed a circular economy roadmap in 2016, which was updated in 2020. The roadmap outlines the country's strategic priorities and action plans to promote a circular economy across various sectors, including construction, biomass, and plastics (Sitra, 2016). Moreover, the Finnish government has implemented several policies and regulations to promote the circular economy. These include waste management policies, landfill taxes, and extended producer responsibility schemes. In addition, Finland has adopted the EU's Circular Economy Action Plan, which includes measures such as eco-design standards and recycling targets. In addition, according to the ‘Strategic Programme to Promote Circular Economy’, proposed by the Ministry of the Environment, 41 measures will be implemented to encourage municipalities and private companies to convert to a CE model. For example, different taxes can be adjusted to promote CE business model and operation (YM, 2022); potential CE projects will be sponsored as a part of the EU’s Recovery and Resilience Facility (Business Finland, n.d.).

In terms of research and innovation, Finland supports research and innovation in the circular economy through funding programs and research institutions. For example, the Strategic Research Council (SRC) has funded research projects focusing on circular economy principles, and the VTT Technical Research Centre of Finland conducts research on resource-efficient production and consumption. As for experiments and demonstration projects, the Finnish government supports various experimental and demonstration projects to showcase circular economy practices. For instance, the ‘Kiertokaari’ project aims to develop innovative solutions for waste management. Finally, the Finnish National Agency for Education has integrated circular economy principles into

its curriculum, and the Circular Economy Competence Center provides training and support for organizations interested in adopting circular economy practices.

2.3.3 Current Situation

Despite the country's determination to be a CE frontrunner, Finland seems to fall behind its EU peers (Fura et al., 2020). As acknowledged by the Finnish government, Finland's indices for Eurostat's CE indicators fall into the middle tier compared to other EU member states. Moreover, Finland's circularity rate (CR) was 2.0% in 2021, strikingly low compared to its CR of 13.5% in 2010, EU's average of 11.7% (2021), and the frontrunner Netherlands with 33.8% (2021). Set in the overall outlook for all EU member states through the decade, Finland fell from the 5th position to second to last in terms of CR rate. In other words, while other European countries are actively and successfully improving their CR, Finland is witnessing stagnation or even regress (Eurostat, 2023).

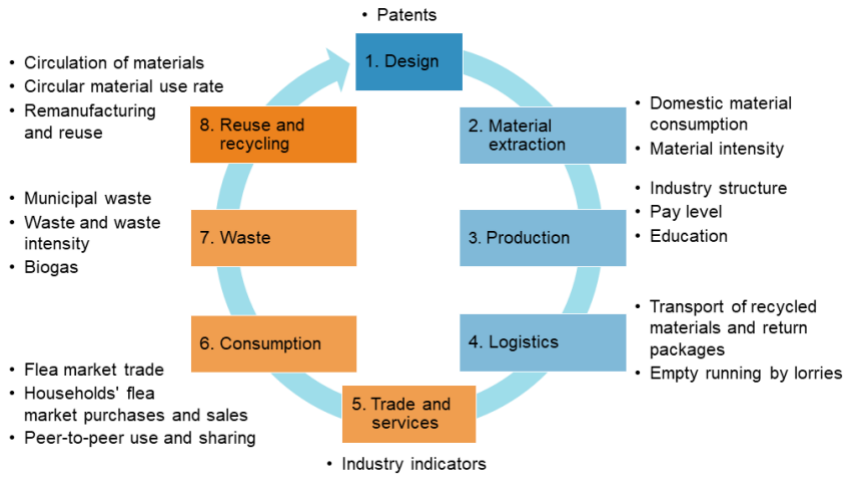

Figure 4: Indicators for the circular economy (Statistics Finland, n.d.)

Alternatively, the assessment of CE progress in Finland might not be reliable when other aspects of CE besides waste management are not covered. As mentioned in sub-section 1.2.1, the currently common CE monitoring tools tend to revolve around waste. Moreover, comparison is unlikely to be accurate when other EU member states do not use the same metrics as Finland. Specifically, in 2020, Statistics Finland released a set of 15 indicators to measure advancement in eight CE activities: (1) design, (2) material extraction, (3)

production, (4) logistics, (5) trade and services, (6) consumption, (7) waste, and (8) reuse and recycling. When the indicators were updated in 2022, three more specific indicators were added while the number of activities remained unchanged. Out of 18 indicators, only three can also be found in Eurostat's, namely (1) number of patents related to circular economy, (2) amount of municipal waste, and (3) total amount of waste and total waste intensity. The rest of 15 indicators are inspired by UN indicators for sustainable development, previous statistics by Statistics Finland, or other Finnish organizations and authorities (Statistics Finland, n.d.).

2.4 Digital Technologies for Circular Economy

Achieving a circular economy (CE) is a challenging task, and digitalization has been identified by several authors (Sullivan and Hussein, 2020; Kottmeyer, 2021) as a crucial driver to accomplish the CE goals. However, the connection between CE and digitalization remains more theoretical than empirical (Parogopoulos, 2017; Alhawari et al., 2021), with current literature tending to focus on their interaction in specific sectors or industries (Chauhan et al., 2022). To address this gap, scholars such as Parogopoulos (2017) and Chauhan et al. (2022) have attempted to synthesize the fragmented literature to provide a comprehensive understanding of the relationship between CE and digitalization, as well as how digital technologies can contribute to CE development.

Among the digital tools that can facilitate CE, IoT, Artificial Intelligence (AI), and Big Data analysis are frequently discussed, followed by social media and blockchain technology. The deployment of AI can boost productivity by enhancing optimization, real-time data processing, and design, thereby promoting circularity (Ghoreishi and Happonen, 2020). Furthermore, big data-driven supply chains influence the connection between resource management and company performance in the context of CE (Del Giudice et al., 2020). Blockchain technology provides decentralized and trustworthy data, improved transparency, intelligent contracts, and traceability, which all contribute to better supply chain performance (Groening et al., 2018). Digital marketing helps bridge communication between businesses and markets, encouraging the adoption of CE principles (Tkachuk et al., 2020). Although technologies like 3-D printing, cloud computing, machine learning,

and virtual reality have been explored, they apply to specific situations. Policymakers are also keen on leveraging digitalization's potential to expedite the transition towards a circular economy. In fact, the European Union's industrial strategy highlights the "twin transition" of green and digital as a unique opportunity for the EU to assert its global leadership and competitiveness (Eurofound, 2020). This reflects a growing awareness among policymakers that digitalization can play a crucial role in realizing the circular economy's potential. Interestingly, recent study (Nguyen & Le, 2022) even discovers a non-linear relationship between digitalization and circularity, suggesting that as circularity levels increase and reach a certain threshold, CE becomes increasingly digital.

2.5 Digitalization in Finland

This section provides information into the situation for digitalization process in Finland.

2.5.1 Initiatives

The Finnish government has implemented several initiatives to achieve its objectives for digitalization. One of these initiatives is the national digitalization program, KIRA-digi, launched in 2016 (Ministry of Economic Affairs and Employment, Finland, 2019). The program aims to promote the digitalization of the construction and real estate sector, thus contributing to Finland's economic growth and competitiveness. As part of this program, the government has introduced a building information model (BIM) mandate for public sector construction projects, which requires the use of digital planning and construction tools (Ministry of the Environment, Finland, 2021). This mandate is expected to improve collaboration and communication between different actors in the construction sector and result in more efficient construction processes. Additionally, the government has invested in the development of digital infrastructure, such as the 5G network, to improve connectivity and enable the use of emerging technologies (Ministry of Economic Affairs and Employment, Finland, 2021). The Finnish government has also established the National Artificial Intelligence Program with the goal of developing and implementing AI solutions in various sectors of society (Ministry of Economic Affairs and Employment, Finland, 2019). One of the key projects under this program is the AuroraAI, which aims to develop a human-centric AI ecosystem in Finland (AuroraAI, 2021). These initiatives

demonstrate the Finnish government's commitment to promoting digitalization across different sectors and ensuring that Finland remains at the forefront of technological advancements.

2.5.2 Current Situation

The Digital Economy and Society Index (DESI) is a composite index developed by the European Commission to measure the digital performance of European Union (EU) countries (DESI, 2022). The index measures a range of indicators across four dimensions: (1) human capital, (2) connectivity, (3) integration of digital technology, and (4) digital public services (EC, 2023). As presented in figure 9, Finland ranks first in the overall performance as well as in the two dimensions of human capital and integration of digital technology.

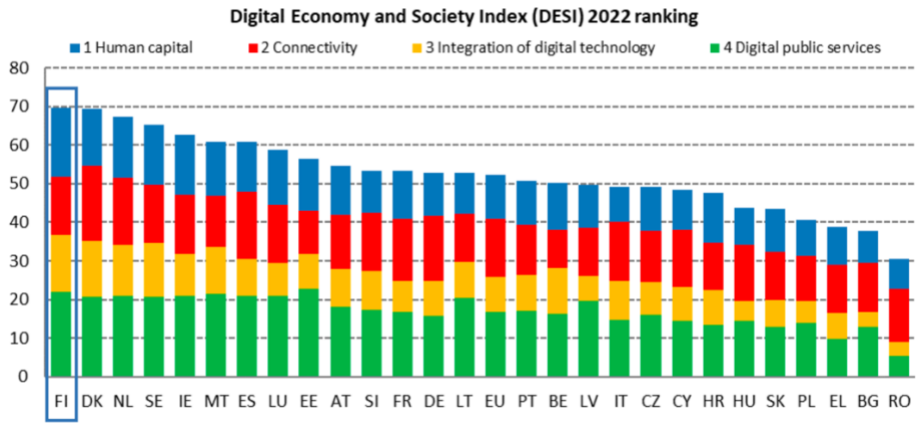

Figure 5: Digital Economy and Society Index (DESI) 2022 ranking (DESI, 2022)

2.6 The Multi-Level Perspective on Socio-techincal Transitions

The multi-level perspective (MLP) on socio-technical transitions, developed by Frank Geels, offers a comprehensive framework to analyze the complex processes that drive transformative change in societal systems, such as energy, transportation, and communication (Geels, 2002). MLP posits that socio-technical transitions occur through interactions among three analytical levels: the socio-technical landscape, socio-technical regimes, and niche innovations. The socio-technical landscape represents the macro-level context, including factors such as cultural values, political beliefs, and global

economic trends, which remain relatively stable over time. Socio-technical regimes refer to the meso-level, where dominant institutions, technologies, and practices shape the rules and structures that guide innovation and maintain the stability of existing systems. Niche innovations, at the micro-level, are novel technologies or practices that emerge and develop in protected spaces, often challenging the prevailing regime (Geels, 2004). Transitions occur when niche innovations gain momentum and destabilize the existing regime, often facilitated by landscape-level changes (Geels, 2002). In later revisions, Geels emphasized the importance of agency, politics, and power relations in shaping transitions, recognizing that actors at various levels can actively influence the direction and pace of socio-technical change (Geels, 2014). In the 2016 article 'The enactment of socio-technical transition pathways', Geels, along with Kern, further refined the typology of transition pathways by offering a more nuanced understanding of how different transition pathways emerge from the interactions between niche innovations and the existing regime (Geels & Kern, 2016). This reformulated typology emphasizes that the development and outcomes of transitions are shaped by the specific context and the strategic actions of various actors at different levels. Overall, MLP provides a valuable lens to explore the complex interplay between technologies, institutions, and actors that shape the dynamics of socio-technical transitions.

2.7 Conceptual Framework

The conceptual framework, based on the MLP (Geels, 2002), aims is to demonstrate the CE transition in Finland from multiple levels. The transition pathway is re-arrangement, where the landscape exerts pressure on the regime such as directives and legislations from the EU. In response, incumbent actors in the linear economy regime lose motivation to compete, creating an opportunity for niche actors. The incumbent actors in this context can be understood as companies, individual consumers, or entities supporting and maintaining the existence of the linear economy. The niche actors can be CE start-ups, CE support groups, governmental bodies and individual consumers who advocate a more circular model of the economy. These niche actors are responsible for introducing radical niche-innovations that compete with incumbents. As the niche gains popularity, the institutional vacuum state ends, and stability returns as niche actors prevail over

incumbents, leading to a rearrangement of the regime, transforming the current economy in Finland into a circular one.

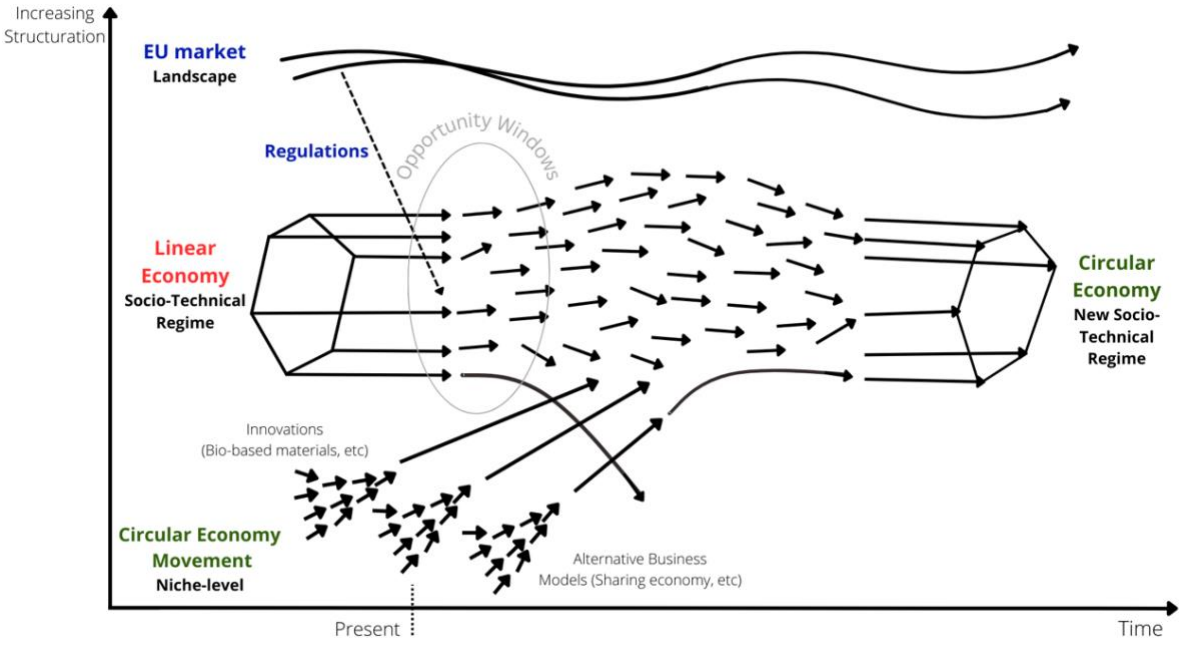

Figure 6: Conceptual Framework

3 METHODOLOGY

3.1 Methodological Approach

The methodology for this bachelor's thesis is grounded in the work of Creswell (2007) on mixed methods design (MMD). The MMD combine both qualitative and quantitative strategies to provide a more complete view of the phenomena under study (Creswell, 2007). The depth of qualitative data and the generalizability of quantitative data enables the identification of trends, patterns, and relationships between circular economy practices and digitalization in the Finnish context. Given the limited number of CE companies in Finland, a purely quantitative approach may not yield sufficient data for statistical analysis. However, by integrating a follow-up survey for the interviewed companies, this mixed methods approach allows for a comprehensive understanding of the digital intensity of these organizations (Creswell, 2007).

3.2 Concurrent Embedded Strategy

This thesis employs the Concurrent Embedded Strategy (CES), which is one among six strategies of the MMD. According to Creswell (2007), the CES includes a single phase for data collection where qualitative and quantitative data are obtained simultaneously. A method is assigned a primary role and the other is given a secondary status. The secondary, embedded method may be dedicated to investigating different aspects than the primary method to provide supplementary data. Within this thesis, the primary method is qualitative, and the secondary method is quantitative. In this case, the inclusion of the quantitative element could provide a more accurate depiction of qualitative study's participants (Morse, 1991).

3.3 Qualitative Data Collection

3.3.1 Interviews

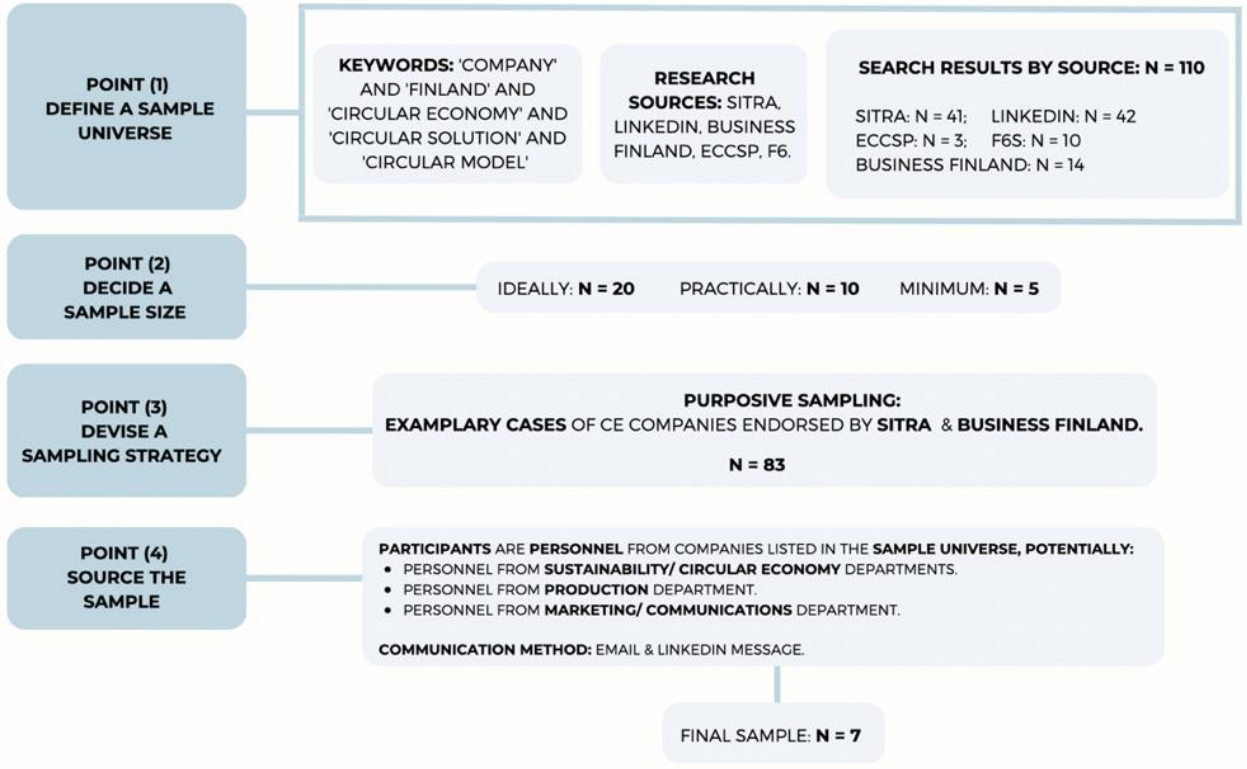

Figure 7: Sampling Process

This thesis employs the four-point approach used in interview-based research (Robinson, 2014). The sampling procedure is depicted in Figure 6, and after the process, a total of seven companies were interviewed. Table 1 provides the profiles of the companies that were interviewed, along with the job titles of the individual respondents.

Company	Respondent role	Industry	Size (Staff)
A	Sustainability & Communications Director	Manufacture of wood-based plastic	Small (10-49)
B	Irresponsibility Coordinator	Army surplus & Outdoor Store	Medium (60)
C	Head of Circular Economy Solutions	Environmental Services	Large (>250)
D	Co-founder & Senior Advisor	Deposit System for Reusable Packaging	Micro (<10)
E	Country Lead (Finland)	F&B Service / Software developing	Small (10-49)
F	Sustainability & Product Specialist	Textile Production & Recycling	Small (10-49)
G	Co-founder & Head of International Growth	Boating Service	Small (28)

Table 1: Profiles of interview participants

The interview questions can be found from Appendix A. The interview questions can be divided into three main parts: (1) Perception of Circular Economy, (2) Circular Economy Ecosystem, (3) Key Capabilities for Circularity, and (4) Digitalization. The first part is based on the literature review to examine how the participant companies perceive CE. The second part is to investigate the companies' awareness and interaction with CE initiatives in both Europe and Finland. The third part is based on Chapter 4 of Sitra's playbook 'Sustainable growth with circular economy business models', and the fourth part explores the plans for digital development by the interviewed enterprises.

3.3.2 Secondary Data

In addition to the primary data obtained from the interviews, the study also analyzed publicly available information on the companies' websites. This strategy aimed to mitigate

the limitations arising from the possibility of respondents' subjective interpretation or inaccurate recall of certain aspects of the company's operations, particularly when their tenure or expertise in the organization is limited to specific functional areas.

3.4 Quantitative Data Collection

After the interviews, a self-administered online survey, using Webropol, was sent to the IT personnel of participant companies. The survey's target population includes all companies participating in the interviews. The goal was to achieve the highest possible response rate from this population. The sampling method is snowball, in which interview participants recommend their companies' IT employees as potential respondents. Companies A, B, D, E, and G proceeded with the survey while companies C and F did not participate, as the latter firm's digital infrastructure was outsourced.

The survey questions can be found in Appendix B. Questions 2 to 5 in the survey are based on the Digital Intensity Index (DII) (EC, 2022). Details on the measuring and evaluating method of the DII can be found in Appendix C. The use of the DII helps to provide a standardized and objective measure of digital intensity that can be easily compared across different enterprises. Question 6 in the survey lists a number of digital technologies with high potential for CE. The technologies included were selected from the work by Chauhan et al. (2022) and Parogopoulos et al. (2017). Questions 8 and 9 inquire about the establishment year and size of the companies to indenfity the corressponding participants from the interviews.

3.5 Data Analysis

Given the use of the CES, the data analysis process for this study was divided into two phases, with qualitative data analyzed separately from quantitative data before both sets were integrated for the final synthesized analysis (Creswell, 2007).

3.5.1 Qualitative Data Analysis

The study follows the Thematic Content Analysis (TCA) approach, as described by Anderson (2007). Firstly, the interviews were transcribed into text format. Next, relevant

information was highlighted and coded into ‘units’. These units were then organized into categories based on their level of relevance to the research topic. Finally, themes were identified and labeled according to the categories. The TCA approach enables a systematic and comprehensive analysis of qualitative data, which allows for the identification of patterns and relationships in the data (Anderson, 2007).

3.5.2 Quantitative Data Analysis

The collected survey answers were used to calculate the DII of the surveyed enterprises, which were subsequently assessed in relation to the number of digital technologies and the provider of such services (internal or external). The analysis aimed to identify any correlations that may exist, and to determine if the companies could be classified into subgroups based on similar patterns. The DIIs of the survey respondents were also compared to those of enterprises in Finland and other EU member states to determine their position in the EU market in terms of digital competence. The specific digital tools used by the studied companies will also be analyzed in the same manner.

3.5.3 Integration of Qualitative and Quantitative Data

The themes identified in the qualitative analysis were integrated with the results of the quantitative analysis to identify potential explanations for the phenomena observed.

3.6 Ethical Considerations

Participants were informed of the thesis’s purpose, the voluntary nature of participation, and the confidentiality of the information provided. Informed consent was obtained prior to the interviews and at the beginning of the survey. All data collected were anonymized. Any identifying information was removed to protect the privacy of the participants.

4 FINDINGS

This section presents the findings from the interviews, secondary information obtained from interviewed companies’ websites, and the follow-up (online) survey. Emerging themes from interview participants’ answers are identified and outlined in thematic breakdown tables accordingly, and survey responses are summarized in three tables.

4.1 Perception of Circular Economy

Theme	Reported by (number of respondents)
Lack of the need for an official definition	2
Multi-dimensional nature of CE	7
Definition is a synthesis of multiple sources	2
Definition is subject to the specific industry	5
Emphasis on the practical applications of CE	3
CE is defined in relation to (EU) regulations	1

Table 2: Thematic breakdown of answers about perception of CE

Regarding the conceptualization of CE, none of the companies adopts a specific definition from a single (scholarly) source. In fact, company G appears to be the closest to having an academia-inspired definition. According to respondent G, their personnel, with backgrounds in Sustainability Sciences, utilizes knowledge of existing theories and frameworks in internal discussion about Sustainability, including CE. Meanwhile, respondent D noted that basic principles of CE are ‘quite common concepts’ and ‘more of an inspirational thing’. Respondent B also described their understanding of CE as ‘a combination from different sources’ that has been ‘distilled into’ their company culture.

Company A and E do not attempt to define CE. Rather, they acknowledge the alignment of their operation with CE principles.

> This is our way of doing business, and it’s good if it fits the circular economic concept (Respondent A).

Indeed, the companies’ perception of CE is circumscribed by their industries and business fields. All respondents shared the idea that CE, as a concept, could be very wide and consists of many elements. Therefore, companies such as A, C, and F prefer to highlight the practical aspects. For example, as an environmental service provider, company C defies CE based on EU regulations on waste materials.

The key word ‘material’ is the most repeated term among all interviews conducted, as illustrated by figure 7. Other common phrases include ‘resources’, ‘efficiency’, ‘waste’, ‘end-of-life’.

Figure 8: Word cloud based on collected responses

4.1.1 The Essence of Circular Economy

Theme	Reported by (number of respondents)
Reduce (consumption)	7
Reuse	3
Recycle	2
Recover	1
Repurpose	1
Redesign	3

Table 3: Thematic breakdown of answers about the Rs frameworks

All companies are familiar with the Rs frameworks. On their website, company A regards the 7Rs (reduce, reuse, redesign, repair, refurbish, return & recover, recycle) as the basics of CE. During the interview, respondent C cited the 4Rs (reduce, reuse, recycle, recover). Moreover, respondent B revealed that the 3Rs was used as a ‘pyramid for priorities’ in their company. On the other hand, not all elements (R-imperative) receive equal attention. Table 3 summarizes the R, both implicitly and explicitly, favored by the respondents.

According to respondent A, recycling alone cannot address the problem of mounting waste. A then suggests that product redesign can address the root of the problem. Company A, for instance, follows this approach by manufacturing plastic made of renewable, non-fossil biomaterials that are easy to recycle. Similarly, respondent E highlights the importance of smart design throughout the value chain to prevent inefficiencies and waste. Their business model, a platform for surplus food reselling and purchasing, exemplifies how a linear economy is still not optimal, and waste and inefficiencies can still occur.

However, most respondents agree that reducing production by keeping existing materials in circulation is a crucial goal of the circular economy. This can be achieved through reusing, recycling, and repurposing. Respondent C, however, believes that reducing production has both benefits and drawbacks. For instance, reducing plastic packaging for certain food products may pose safety concerns. Nonetheless, C supports the idea of recycling and reusing plastic and proposes regulating recycling materials, especially for industry-level stakeholders. Most importantly, recovery of waste is at the core of company C's operations, with the aim of turning end-of-life waste into resources again for a new process, thereby reducing the amount of face and raw materials used.

Company D's business idea focuses on reusable packaging for takeout food. Respondent F suggests combining reducing production, recycling, redesigning, and repurposing. As F pointed out, the (re)design of materials to make them easier to recycle overall enhances resource efficiency. F also proposes giving end-of-life products new ideas or purposes to extend their lifetime. Respondent G shares the goal of repurposing and efficient use of resources. Furthermore, G's business model also involves shifting from owning to sharing resources.

4.1.2 Circular Economy and Sustainable Development

All respondents agree that CE and SD overlap in areas such as resource depletion and waste management, although SD encompasses a wider range of issues. Respondent A views CE as a component of the broader concept of SD. Respondent B agrees with this

view but also notes a distinct difference. While SD implies growth and consumption at a sustainable level, CE promotes circularity to minimize material extraction. Respondent E sees CE as a critical approach to SD that reduces environmental impacts while still promoting economic activity. Respondents C and G emphasize the social aspects of SD, such as health, ethical working conditions, and consumption patterns, in addition to biobased issues. CE, on the other hand, aims to create value through a non-linear material life cycle. Respondent D concurs with this view, considering CE a tool for utility maximization, while SD takes a broader approach with considerations for future generations. Finally, respondent F perceives CE as a specific approach to resource efficiency and organizational cooperation, while SD is a more comprehensive framework of actions.

Theme	Reported by (number of respondents)
CE is a component of SD	2
CE is a mean to achieve SD	4
CE has little emphasis on the social aspect	3
CE is a tool for waste and resource management	3
SD is broader in terms of scope	7

Table 4: Thematic breakdown of answers about CE and SD

4.2 Roles of Stakeholders

Theme	Reported by (number of respondents)
Government sets (strategic) CE goals	3
Government establish CE regulations	6
Companies and customers are the main actors	3
Customers are the most important actor	3

Table 5: Thematic breakdown of answers about the role of different actors

All respondents acknowledge the role of the government in setting strategic CE goals, introducing new regulations, and providing support to motivate companies and customers. However, they also recognize the limitations with the current legislations. Respondent C mentions the challenge of changing waste material status to serve as material. While respondent A understands the necessity of ambitious goals, there are concerns regarding practicality. Meanwhile, respondent F expresses uncertainty about

the efficacy of strict regulations in promoting CE. Respondent E adds that the (Finnish) government should also reverse incentive practices contradicting CE principles.

Respondents B, D, and G share the view that companies and customers are the two most important players, who collaborate, to drive the transition to CE. Respondent B argues that companies have a responsibility to educate consumers and make it as easy and attractive as possible to participate in circular economy practices. However, while the responsibility for cultural change lies with consumer culture as a whole, powerful players such as the media can help drive the transition.

> I believe that consumers do lead the way in [the] cultural transition into [...] making reuse socially acceptable and the norm, but if the companies don't make that transition easy for the consumers, it's not going to happen (Respondent B).

According to respondent D, companies are often the leaders in driving the transition, even ahead of the government. However, ultimately, everything narrows down to customer preferences and consumption patterns, although involving and incentivizing consumers in CE activities can be a challenge. Respondent G suggests that companies should make circular economy practices easy for consumers by designing products that are easy to reuse or recycle. G gives an example of how their company is promoting circular economy in the boating industry, by encouraging customers to share resources and reuse materials rather than building new boats.

Respondent A places great importance on customers' insights and actively engage the customers in the early stage (design) of the full product life cycle.

> At the end of the road, consumers are a really critical stakeholder. We have also done research with our consumers [to investigate] how they see and appreciate a new type of plastic material (Respondent A).

Respondents C and E agree that the realization of CE hinges upon the influential power of consumers.

> Consumers are the most [important]. In many cases, they're the end-users [who set] requirements for the companies. That is changing the playground (Respondent C).

In addition, respondent E believes companies, for long-term survival, should proactively improve and renovate their products even before consumers start demanding changes.

Finally, respondent F does not prioritize any particular stakeholder. To promote CE, consumers should demand transparency of product information to make informed buying decisions. While the government supports companies and consumers through guidance, promotion, and awareness campaigns, companies comply should design products to be easily repaired, reused, or recycled.

4.3 Circular Economy Ecosystem

4.3.1 Ecosystem

Theme	Reported by (number of respondents)
Awareness of CE initiatives	7
Invitation to CE events	2
Limited engagement	3
Active engagement and collaboration	4
Funding recipients	3
Membership	2

Table 5: Thematic breakdown of answers about level of involvement in CE initiatives

Companies B and E, although they have recently received some invitations for CE projects and conferences. Company G is aware of circular economy programs but not actively involved in them, instead more involved in Sitra. By contrast, company A closely collaborated with VTT, the Finnish Research Institute, and received funding from Business Finland for a number of CE-themed projects. Company F has also benefited from Business Finland' financial support and launched a project to upscale their business model globally. Company D was partially funded by the Ministry of the Environment and Horizon 2020, EU's research and innovation funding program from 2014-2020 (EC, n.d.). Regarding membership, company C is a member of the Climate Leadership Coalition,

while company F is a part of the Telaketju network, a platform dedicated to textile recycling (Telaketju, n.d.).

4.3.2 Partnership

Theme	Reported by (number of respondents)
CE is one of the selection criteria	6
CE is not a deal-breaker	1
Lack of CE-oriented subcontractors	2
Sustainability is an important criterion	4
Use of established standards to evaluate sustainability level of subcontractors	3

Table 7: Thematic breakdown of answers about CE as a criterion for subcontractors

Overall, the respondents have varied perspectives on prioritizing partners and subcontractors with circular economy in their agenda. Respondent A suggests that including circular economy as part of the discussion could be a good idea, while respondent B states that it is a factor but not a deal-breaker. Respondent C confirms that they have requirements for partners and subcontractors, including ESG and CSR criteria, for evaluation. Respondent D highlights the importance of properly recycled packaging and using Life Cycle Assesement studies to validate sustainability criteria. Respondent E notes that they prioritize sustainability in multiple aspects, such as office supplies, furniture, and software vendors. Respondent F anticipates an increase in the number of subcontractors interested in CE, although there are presently relatively few such actors. Respondent G concurs with this viewpoint while emphasizing their dedication to promote CE, indicating they regularly question their partners and subcontractors on this matter.

4.4 Organization and Culture

4.4.1 Circular Solutions

Table 8 provides a comprehensive overview of the companies' original business models, including their founding year, as well as information on the circular solutions they have implemented, and the year they were launched. Examination of this information yields insights into the evolution of the companies' business strategies and the extent to which they have embraced the principles of the CE.

Company	Original Business Model (OBM)	Year Founded	Circular Solutions	Year launched
A	Inventing wood-based material for plastic manufacturing	2011	Same as OBM	2011
B	Selling army surplus to individual consumers	2003	Return program for purchased goods	2017
C	Waste collection and management	1964	Recovering construction waste into usable materials	2021
D	Reusable packaging in a digital deposit-based system	2018	Same as OBM	2020
E	Selling individual consumers discounted surplus food from F&B businesses	2015	Same as OBM	2016
F	Manufacturing durable workwear	2008	Manufacturing durable workwear from recycled materials	2017
G	Subscription service for boating; Sharing platform for people to rent boats or put boats for rent	2017	Same as OBM	2017

Table 8: Company circular transition timeline

4.4.2 Inclusion of Circular Economy in Sustainability Reporting

In relation to the third and fourth columns, the integration of the Circular Economy (CE) is indicated by the explicit and clear usage of the term ‘Circular Economy’.

Company	Sustainability Reporting (public)	Inclusion of CE in Sustainability Reporting (public)	Inclusion of CE in website content
A	X	X	X
B	X	X	X
C			X
D	X	X	X
E	X		
F	X	X	X
G			

Table 9: CE inclusion in sustainability reporting and website content by participants

4.4.3 Measuring Progress

Theme	Reported by (number of respondents)
No CE indicator	1
Metrics related to recycled materials	4
Metrics related to customer satisfaction	2

Table 10: Thematic breakdown of answers about CE indicators

Company A is in the early phase of concept development and therefore does not have any quantifiable metrics available to measure CE progress. In the (near) future, they may measure the number of recycled materials. Respondent B describes the metrics related to their resell program such as the number of resold products, webstore orders, and credits that customers receive for reselling products. The respondent also mentions that the company calculates the amount of recycled raw materials or fabrics used every two years. Company C collects data from the whole value chain, including information about the type of material collected, logistics, and the quality of the material. They use this data to track metrics related to the material and CO2. Company D tracks service units per package and return rates for measuring efficiency. Company E follows metrics related to saved portions, while Respondent F tracks energy and resource consumption and customer usage. Lastly, respondent G uses metrics to calculate resource efficiency and customer engagement level.

4.4.4 Circular Economy Skills Building

Theme	Reported by (number of respondents)
No specific CE training	7
Potential future use of sharing platform(s)	1
Provider of sharing platforms	3

Table 11: Thematic breakdown of answers about CE skills building for employees

All respondents acknowledge that there is no training specifically addressing CE for their personnel. However, since CE is embedded in their company culture and operation, their employee development programs could be of relevance. For example, company B has designers who use recycled materials, but no other specific training related to CE. Company C's training covers different aspects of waste legislation in order to keep the staff updated with new regulations. Company E emphasizes on-the-job learning about

food waste, a problem CE means to solve. Respondent F provides training on resource efficiency, and respondent G provides webinars on sustainability topics, including CE.

4.5 Functions and Innovations

Theme	Reported by (number of respondents)
No current use of sharing platforms	2
Potential future use of sharing platforms	1
Considerations for restart of a sharing platform	1
Provider of sharing platforms	3

Table 12: Thematic breakdown of answers about the use of sharing platforms

Companies D, E, and G have taken on the role of providers of their own sharing platforms due to the nature of their business. Respondent B mentions that they previously ran a camping rental service. However, the rental scheme was not a core part of their business and was eventually shut down due to financial loss. Respondent F shares that their company will be using shared facilities such as electric bikes and conference rooms when they move to a new facility, but currently does not utilize any sharing platforms. Company A does not provide nor receive services from any sharing platforms.

Theme	Reported by (number of respondents)
Interest in new digital technologies	2
Little to no room to be more digitalized	3
Research into new digital technologies	2
No immediate need to be more digitalized	2

Table 13: Thematic breakdown of answers about the adoption of new technologies

There is a general sense of awareness and anticipation for new regulations and initiatives that will require companies to track the origins and lifecycles of products. Respondent C and E are specifically interested in finding more efficient ways to work and reach customers and partners through the use of digital technologies. Respondent E is already exploring new tools and interested in AI. Respondents differ in their current level of use of new digital technologies. Respondent A is conducting research, Respondent B has a digital structure for their circularity program, , Respondent D has already built back-end systems. Respondent D, E, and G already considers themselves highly digitalized and

does not see room for improvement. However, they (A) do offer remote work opportunities and recognize the need to become more digitalized in the future to improve their supply chain processes and facilitate recycling for consumers.

Theme	Reported by (number of respondents)
Digital training for all employees	1
Digitally savvy employee base	3
Need-based digital training for employees	2
No digital training for employees	1
Opportunities for remote work	6

Table 14: Thematic breakdown of answers about digital training and remote work

The responses demonstrate three distinctive patterns with regards to digital training. Firstly, respondent A states that they currently do not provide digital training to employees. Respondent E and G rarely provides digital training, given that most employees are digitally-savvy. Secondly, companies B and F offer digital training upon particular request, with F provides financial resource for employees to purchase online courses throughout the year, especially when a new digital tool or software is introduced. Thirdly, company D provides digital training to all employees as their product involves digital features. All companies offer remote work opportunities to most employees unless it is necessary for them to be physically present to complete their tasks.

4.6 Challenges

The challenges that participant companies face in implementing CE are diverse and complex. Respondent A identified the small volumes of recyclable materials in the market as the biggest challenge. Recycling companies are not incentivized to collect and sort these materials. However, they remain hopeful that there will be financial benefits for everyone once the demand for recycled materials increases. Respondent B mentions the balancing act of encouraging customers to buy products that last a lifetime and grow their program, while also avoiding overconsumption. They highlightt the risk of declining availability of army surplus, which is a significant share of their business. Respondent B also notes that armies may start to develop their own circular economy programs, leading to uncertainty in supply. Respondent C points out that combining different materials in

clothing, such as cotton, plastic, and metal, makes it challenging to recycle them. High-quality handling facilities are required, but there is a lack of a business case for this. Developing technologies, such as chemical recycling, may offer some solutions, but the energy efficiency of these processes is not always sufficient. Respondent D mentions the challenge of getting consumers to adopt circular economy practices. Respondent E emphasizes the difficulty of convincing restaurants and cafes to acknowledge and address food waste as a problem. While some grocery stores have strategies in place, restaurants and cafes often continue to produce surplus food and dispose of it without considering the consequences. Respondent F regards to the logistics of recycling used clothing. Furthermore, fabric suppliers are hesitant to share detailed information about their materials, which can make it difficult for companies to ensure the sustainability of their products. Respondent G identifies their business goal to be the shift from ownership to shared use in the boating industry. This change in mindset of the consumers is not easy to achieve.

Theme	Reported by (number of respondents)
Balancing the promotion of durable goods and avoiding overconsumption	1
Business secrecy hinders co-operation	1
Customers lack incentives to practice CE	1
Declining amount of surplus goods	1
Denialism of food waste	1
Difficulty in changing customers' mindset	2
Difficulty in recycling mixed materials	1
Difficulty of reverse logistics	1
Lack of co-operation from incumbent actors	3
Non-guaranteed energy efficiency of chemical recycling	1

Table 15: Thematic breakdown of answers about challenges

4.7 Survey results

Table 16, 17, and 18 summarize the results for questions 2 to 7 of the survey.

	Company				
	A	**B**	**D**	**E**	**G**
Number of Digital Technologies utilized	**3**	**5**	**7**	**6**	**6**
Artificial Intelligence & Machine learning		**X**		**X**	**X**
Automatic identification			**X**		
Big data analytics			**X**	**X**	**X**
Blockchain/ Distributed Ledger Technologies					
Cloud Computing	**X**	**X**	**X**	**X**	**X**
Digital fabrication/ Digital-twin/ 3-D Printing			**X**		
Internet of things (IoT)		**X**	**X**		**X**
Product Life Cycle Management (PLCM) Software			**X**	**X**	
Robotics					
Social media	**X**	**X**	**X**	**X**	**X**
Mobile application	**X**	**X**	**X**	**X**	**X**

Table 16: Results for question 6

Ranking	Company	Digital Intensity Index	Digital Intensity Level
1	**B**	11	Very high
2	**G**	11	Very high
3	**D**	11	Very High
4	**E**	8	High
5	**A**	5	Low

Table 17: Results for questions 2 to 5

Provider of digital technologies	Company				
	A	B	D	E	G
Internal IT Department		X	X	X	X
Outsourcing Partners	X				

Table 18: Results for question 7

5 DISCUSSION

5.1 The Influence of Perception on Circular Economy Implementation

Overall, participant companies are less focused on the origin and evolution of CE than its real-life applications. A plausible explanation is that companies are introduced to CE through the EU's legislative measures, rather than scholarly sources. Moreover, in line with Kirchherr et al. (2017), the companies have varied understandings of CE, which are often shaped by their industry, business field, and the information they gather from different sources. This supports the idea that there is no single, universally accepted definition of CE, and companies tend to adopt a context-specific approach to understanding and implementing CE principles. Secondly, Ghisellini et al. (2016) highlight that companies often adopt CE strategies to improve resource efficiency and reduce waste, which can lead to cost savings and enhanced competitiveness. This is consistent with the results presented in the word cloud (Figure 7) with 'resources', 'efficiency', and 'waste' being the most repeated terms just after 'materials'.

Lieder and Rashid (2016) suggest that companies should develop suitable performance indicators that align with their specific CE goals and objectives. Again, the companies track various metrics that are specifically related to their industry and business models, instead of indicators strictly designed to measure CE progress, such as those initiated by Eurostat or Statistics Finland. This is in line with the conclusions by Pascale et al., (2021) and reflects the common practice of using tailored performance indicators to evaluate the effectiveness of CE practices among private enterprises. In terms collaboration for CE implementation, the studied firms have different approaches to prioritizing partners and subcontractors. Companies with more concrete CE definitions and utilize more indicators

to measure CE progress also require adherence to ESG and CSR criteria or prioritize sustainability when selecting subcontractors, while others consider CE as a factor but not a deal-breaker.

5.2 Circular Economy Ecosystem

All participants are aware of CE initiatives, projects, and regulations from the EU and the Finnish government, despite the varying degree of attention and commitment. It appears that company engagement with CE is more commonly observed on a case-by-case basis, rather than a collective movement. Alternatively, companies may join projects with broader themes that incorporate CE as one aspect among many, such as the case of company C. Furthermore, the collaboration among the interviewed companies appeared to be predominantly vertical in nature, with entities from different levels of governance collaborating rather than actors at the same level of governance engaging in collaborative efforts.

5.3 Policy Analysis

Based on the work by De Bruin et al. (1993), Geels et al. (2015) presents the three policy paradigms that policymakers could adopt to achieve system innovations (Figure 8). Given the contextual information in the literature review and findings from interviews, it appears that the Finnish government's policy approach is a mix of interactive network governance and market model approaches.

From the perpsective of certain participants, the (Finnish) government is responsible for defining CE targets, but the main actors responsible for execution are companies and customers. This perception of government’s role fits in the market model (bottom-up) policy approach (Geels, 2019). This observation is in line with previous studies about CE implementation in Europe. Ghisellini et al. (2017) points out that European countries, Finland included, prefer ‘bottom up’ method by involving the cooperation of (CE) actors from various levels.

	Classic steering (top–down)	Market model (bottom–up)	Interactive network governance
Social relationships	Hierarchical, command-and-control relations, with government responsible for steering markets and society	Arms-length relations between policymakers and other actors	Mutually dependent interactions between policymakers, firms and societal actors
Government roles	Government sets goals, selects solutions, and enforces implementation	Policymakers shape framework conditions (rules, incentives), but let autonomous actors self-organize via markets	Policymakers moderate, orchestrate, and facilitate social interactions, discussions, learning processes and information exchange, aimed at collectively defining problems and exploring solutions
Scientific disciplines	Classical political science	Neo-classical economics	Sociology, innovation studies, neo-institutional theory
Policy instruments	Regulations, laws, performance standards, targets, state-led investment programmes	Subsidies, taxes, fiscal incentives, grants, loans	Sector-level round tables, public private partnerships, demonstration projects, experiments, foresight conferences, public debate

Figure 9: Stylized summary of different policy approaches (Geels, 2019)

As for the application of the interactive network governance, the Finnish government has placed significant emphasis on stakeholder engagement, cooperation, and knowledge sharing. Initiatives like the Sitra and similar collaborative platforms enable dialogue between government, industry, academia, and civil society, fostering a shared understanding of CE. However, the effectiveness of these initiatives in building a collaborative CE ecosystem in Finland remains uncertain, as not all companies interviewed, including those regarded as CE pioneers by Sitra, report active engagement in these government-led efforts. Furthermore, the observed collaborations are often vertical, involving enterprises, government bodies, and government-funded organizations, and not horizontal. Only companies C and F reported membership in larger organizations that engage in knowledge sharing and collaboration towards a collective goal. These observations raise concerns about the efficacy of the government's interactive network governance approach, especially when network building and

collective visioning are essential during the infancy period of transition process (Roberts & Geels, 2019).

That said, there are policies by the Finnish government that fall under the Classic Steering approach. As observed by participants, the Finnish government also enact laws, such as the Waste Act, to set the regulatory framework for the CE and ensure a minimum level of environmental protection. However, this approach is less visible and emphasized.

On analyzing Finland's policy program(s) for CE, Lazarevic et al. (2022) developed a revised transformative outcome framework (TOF) based on earlier literature by Ghosh et al. (2021) and Kanger et al. (2020). A full description of the revised TOF can be found in Appendix D. According to Lazarevic et al. (2022), the Finland's strategic program(s) mainly highlight niche stimulation and niche acceleration. On the other hand, policies dedicated to opening up and unlocking regimes are quite limited both in terms of quantity and impact. Hence, the nature of CE movement in Finland can be described as 'progressive system change' (Laatsit et al., 2022), which refers to the building up of incremental changes over time for a cumulative configuration. This speculation is indirectly illustrated by the respondent F's concern for counter-productive outcomes should companies be pressurized by the government. Indeed, Finland is viewed as a 'corporatist' country (Jahn, 2016), which is characterized by the heavy influence of (pro-economy) interest groups on the initiation of policies (Pallesen 2006; Vesa et al., 2018).

Nevertheless, given Finland's ambitious goals for CE and underperforming climate mitigation result, stronger measures might need to be introduced. Finland is not the only country with a weak and inconsistent implementation of climate-related policies, as most countries face the same situation (Kivimaa & Kern, 2016). Respondent C's reference to the difficulty of conversing waste status demonstrates the mismatch between ambitious targets and limited supporting policy of Finland. Respondent E further suggests that the Finnish government should reconsider incentive practices that conflict with CE principles. Currently, the inconsistent participation in CE initiatives, conferences, and networks by specific stakeholders implies that the Finnish government's efforts could be even more

effective. Otherwise, pioneering CE companies like A has full entitlement to feel uncertain about the practicality of ambitious CE goals targets.

5.4 Digital Performance

The following subsections will analyze the findings from the conducted interviews and survey in relation to the information obtained from the DESI report and relevant literature about the impact of digitalization on CE performance.

5.4.1 Human Capital

The DESI report highlights the strong performance of Finland in human capital indicators, such as the proportion of employed people working as ICT specialists, which is nearly 3 percentage points higher than the EU average. Additionally, ICT graduates in Finland account for 7.5% of all graduates, and the share of companies providing ICT training to their employees in Finland is almost twice the EU average (DESI, 2022). The findings by DESI are consistent with the answers by interviewed companies. The studied enterprises do not necessitate frequent training sessions, due to the presence of employees with technical expertise. However, when necessary, the companies offer training opportunities and the requisite resources to enable their workforce to acquire new skills.

5.4.2 Integration of Digital Technology

Two figures below outline the adoption of digital technologies among small and medium-sized enterprises (SMEs). Figure 10 illustrates the digital technologies selected by survey respondents, whereas Figure 11 provides a comparison between the EU and Finland across six categories: (1) the proportion of SMEs exhibiting a basic level of digital intensity, and the percentage of SMEs using (2) cloud computing, (3) social media, (4) IoT, (5) big data analysis, and (6) AI.

The survey revealed that social media, mobile applications, and cloud computing were the three technologies utilized by all enterprises. This finding is not surprising given the high adoption rates of cloud computing and social media in Nordic countries and large enterprises, with 66% and 51% of SMEs in Finland reporting the use of cloud services

and social media, respectively (Eurostat, n.d.). In addition, the extensive adoption of cloud computing supports the finding that remote work is a common practice in the studied companies, reflecting Finland's work culture (Ghose, 2019) and the Covid-19 pandemic (Eurofound, 2020; Alashhab, 2021; Singh et al., 2021).

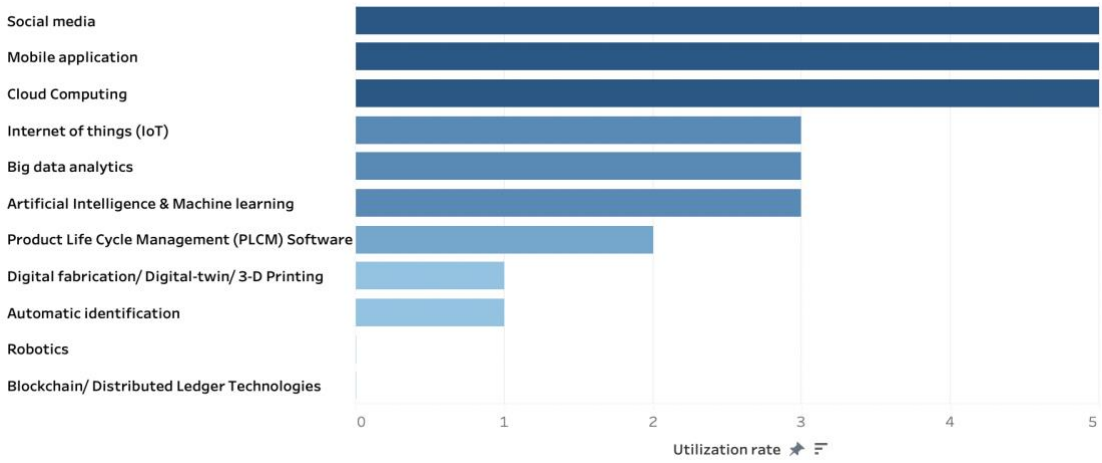

Figure 10: Ranking of digital technologies by utilization rate

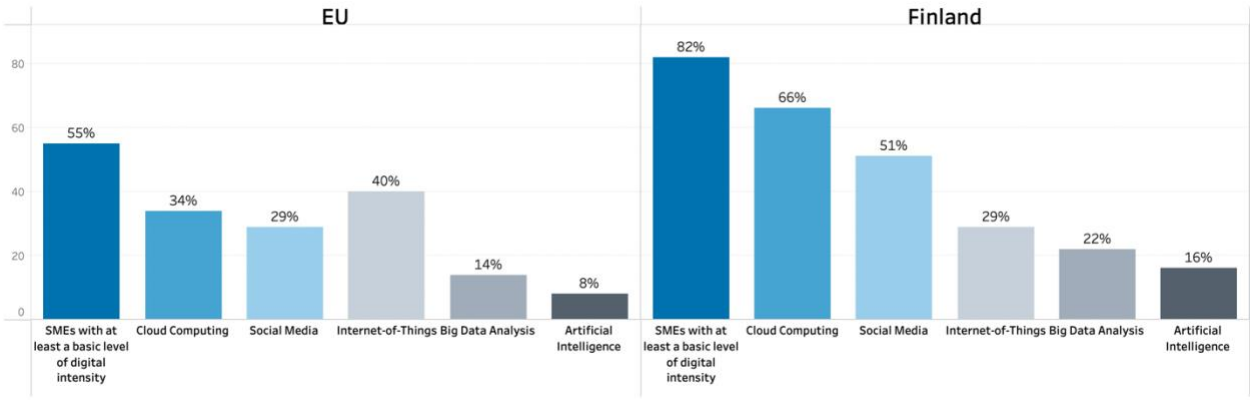

Figure 11: Comparison of EU and Finland for (adapted from Eurostat, 20..)

Regarding social media, its usage has grown exponentially, and it has become a useful marketing tool for enhancing customer relationships (Laroche et al., 2013), including enterprises wanting to promote CE practices to customers (Wynn & Jones, 2022). Moreover, given that most of the survey participants are young B2C companies, social media should be an integral aspect of their marketing strategy (Iankova et al., 2019). Thirdly, mobile applications have become crucial to many business models due to their various features, such as geo-localization, touch screen, and accelerometer (Deloitte

Finance, 2022). For example, Company D's digital deposit system for reusable packaging and Company G's marketplace for surplus food would not be viable without their mobile apps, which are not only technological assets but also fundamental components of their business operations.

IoT, Big Data Analysis, and AI were identified as the second most frequently used digital technologies by the surveyed firms. The literature review confirmed that IoT has significant potential in CE, despite its relatively lower adoption rate of 29% among Finnish SMEs compared to the EU average. In contrast, Finland's adoption rates for Big Data Analysis and AI are double that of other member states, despite relatively low adoption rates across the EU (DESI, 2022). The literature also supports the relevance of these tools for digitalization and CE, and the abundance of skilled ICT specialists in Finland further emphasizes their potential for successful implementation in CE practices.

Regardless of the widespread hype surrounding blockchain technology and the high level of digital intensity of the surveyed enterprises, none of them currently utilize the technology. This may be attributed to several factors, including the challenges associated with its implementation. According to a 2018 survey by Deloitte, although 74% of respondents recognized the compelling business case for blockchain technology, only 34% had initiated any blockchain deployment, indicating that the technology's adoption rate remains low. This is due in part to the significant business model changes that blockchain implementation requires, which necessitate a comprehensive approach to address tax, cyber, governance, and regulatory issues at the organizational level (Deloitte, 2018). Additionally, regulatory frameworks governing blockchain technology remain underdeveloped worldwide and in Europe, with the recent launch of the European Blockchain Sandbox Initiative (EBSI) in 2023 as a noteworthy effort to monitor blockchain deployments with regards to EU regulations. These factors collectively yield insights into the lack of incentive for surveyed enterprises to adopt blockchain technology.

5.5 Breakdown of Circular Companies based on Digital Intensity

Out of five survey participants, four companies that identify themselves as start-ups (A, D, E, G) were all founded in the 2010s and have a micro to small (employee) sizes. Three start-ups D, E, and G are highly digitalized, as demonstrated by their DIIs (8-11) and the number of digital technologies utilized (6-7 tools), while company A appears to be much less digitally developed with a low digital intensity and few digital technologies used. This could be explained by the primary difference in the business orientation and competitive edge between the High-tech cluster (D, E, G) and A.

Specifically, company A's business model is based on their intellectually protected recipe to produce wood-based, carbon-neutral plastic-like material. In this sense, A is more similar to F, a pioneering producer of recycled, carbon-neutral workwear. As part of their closed-loop solutions, F refine end-of-life textiles to create new materials. Additionally, F does not have an internal IT department and, therefore, did not participate in the follow-up survey. While no speculation can be made about F's digital intensity, it appears that the competitive edges of A and F lie in the power of biological technology rather than digital technology.

On the other hand, E and G regard themselves as tech start-ups due to the heavily digitalized infrastructure fueling their (CE) business models. Company D does not advertise as a tech firm, but respondent D, one of the co-founders, positions the company as a sharing platform, which undoubtedly requires a highly digitalized structure. These companies, in fact, can be considered digital companies that pursue circularity (Nguyen & Le, 2022).

Interestingly, company B, the only medium-sized, most long-established enterprise in the survey, is also highly digitalized. This (very) high level of digitalization is consistent with their B2C e-commerce model, especially when 68% of their turnover was from online sales in 2020. Moreover, although B did not actively pursue a CE strategy at its inception, the idea of selling surplus goods is inherently circular since the product lifecycle is extended.

5.6 The Dynamic between Niches and Incumbents

CE companies often identify opportunities by addressing the inefficiencies of the existing linear economy. As a result, the challenges faced by CE companies can be indicative of the resistance of the linear economy to change. On the other hand, the progress made by pioneering CE firms could provide insights into how the existing regime is utilizing niche innovations to address its limitations. Hence, based on the reformulated and differentiated transition pathways (Geels et al., 2016), the interviewed companies will be divided into three groups: (1) Incumbent substitute, (2) Transformative incumbent, and (3) Ally of incumbents. The detailed description of the revised transition pathways (Geels et al., 2016) is displayed in Appendix E.

5.6.1 Incumbent substitute

A is regarded as the incumbent substitute among the seven companies because its wood-based material aims to replace the conventional fossil-based ingredients in plastic production. This is especially crucial given that the majority of current plastic production relies on virgin, fossil-based materials. Therefore, the increasing popularity of A's alternative plastic material has the potential to significantly disrupt and challenge the business models of current companies that provide fossil polymers to plastic manufacturers. As a new entrant, company A faces plenty of challenges, including skepticism from incumbents and a low brand recognition. The low volume of production is both reflective and causative of their challenges. According to Smith and Raven's (2012) framework, A could potentially follow the ‘stretch-and-transform’ substitution pathway. While A's wood-based plastic has superior performance, it cannot offer as competitive pricing compared to incumbent fossil polymer suppliers. Therefore, for A to fully realize its potential and capture a significant market share, external forces such as institutional changes in the landscape will be necessary to disrupt the existing regime.

5.6.2 Transformative incumbents

Company C has a historical background as a waste management firm, established in 1964, prior to the emergence of circular economy (CE) and its increasing popularity in

recent years. In this regard, the company can be considered as an incumbent that actively reoriented itself towards CE, instead of being 'locked in' to the existing regime (Geels et al., 2016). When confronted with the difficulty of recycling materials containing multiple components, C is exploring new technologies and innovations as well as closely monitoring new waste management regulations. With the establishment of a waste refinement plant in 2021, the integration of CE in C's communications and business values, and alignment of fundamental elements such as mission, identity, technology, and marketing with CE values, the company has achieved level 4 in terms of strategic reorientation. Hence, considering the company's long history and current efforts, C can be regarded as a highly transformative incumbent, rather than a new entrant in the CE niche. Similarly, Company B can be considered a CE model at its inception, as the company adopted the surplus selling model. However, when faced with a shortage of surplus supply, B initiated a CE-inspired return program for purchased goods, even though it provided marginal profit. Consequently, it is safe to conclude that B is also a highly transformative incumbent with continuous efforts to adhere to CE principles.

5.6.3 Ally of incumbents

Firms D, E, F, and G are considered allies of incumbents due to their rapid and significant growth as they provide solutions that address the issues faced by existing actors in the regime. In the case of company E, incumbents such as restaurants and cafes, may be hesitant to acknowledge the issue of food waste and therefore resist opportunities for collaboration. Denialism of the issue of food waste is not limited to certain actors within the linear economy, including household consumers. In fact, previous research has suggested that consumers tend to view food waste as a social issue rather than an environmental concern (Parizeau et al., 2015; Wrap, 2006), and may feel it is an inevitable outcome (Graham-Rowe et al., 2014). Nevertheless, by providing a significant discount for surplus food, E is able to appeal to the cost-saving motivation of individuals (Baker et al., 2009; Graham-Rowe et al., 2014) and encourage them to waste less food. Regarding potential business partners, E collaborates with entities that prioritize sustainability over profitability and also experience a surplus of food waste. Similarly, for G, their business model is developing because customers realize the benefits out of their subscription-

based boating service over the traditional practice or owning boats themselves. For D and F, they focus on establishing partnership with existing businesses which have a plan to become more sustainable.

5.7 Revised Conceptual Framework

The revised conceptual framework (Figure 12) envisions a different transition process for the CE movement in Finland. Instead of Re-arrangement, the transition path that Finland might undergo now is Reconfiguration, with elements adapted from the Transformation pathway.

The Reconfiguration path is characterized by the integration of niches by incumbents due to the symbiotic relationship between the actors from both levels (Geels, 2011). In the context of this study, companies D, E, F, and G are slowly penetrating the regime when incumbents such as individual consumers and business firms realize the benefits they offer and form an ally. In addition, within this trajectory, innovations from the niche level have greater prospects for development when the regime is compelled to respond to pressures from the landscape. For biotechnology-backed start-ups with a moderate growth rate like A, stricter (waste management/ resource efficiency) regulations from the EU could drive the demand for their circular solutions. On the other hand, the revised conceptual framework also includes elements found in the Transformation pathway. Specifically, upon recognizing the changing landscape, incumbents also undergo changes in multiple aspects to avoid being wiped out when the current regime ceases to exist. The transition towards CE is a complex and multifaceted process that is not always clear and straightforward (Wynn & Jones, 2022).

The complex process of shifting away from the traditional ‘take-make-dispose’ practices towards circular economy requires considerable time and effort. Finland, like many other countries, is in the early stages of incorporating CE innovations into its economy, while existing actors are adapting to align themselves with the CE trend. However, in the long term, the gradual integration of niche innovations and practices into the existing regime could catalyze significant transformations.

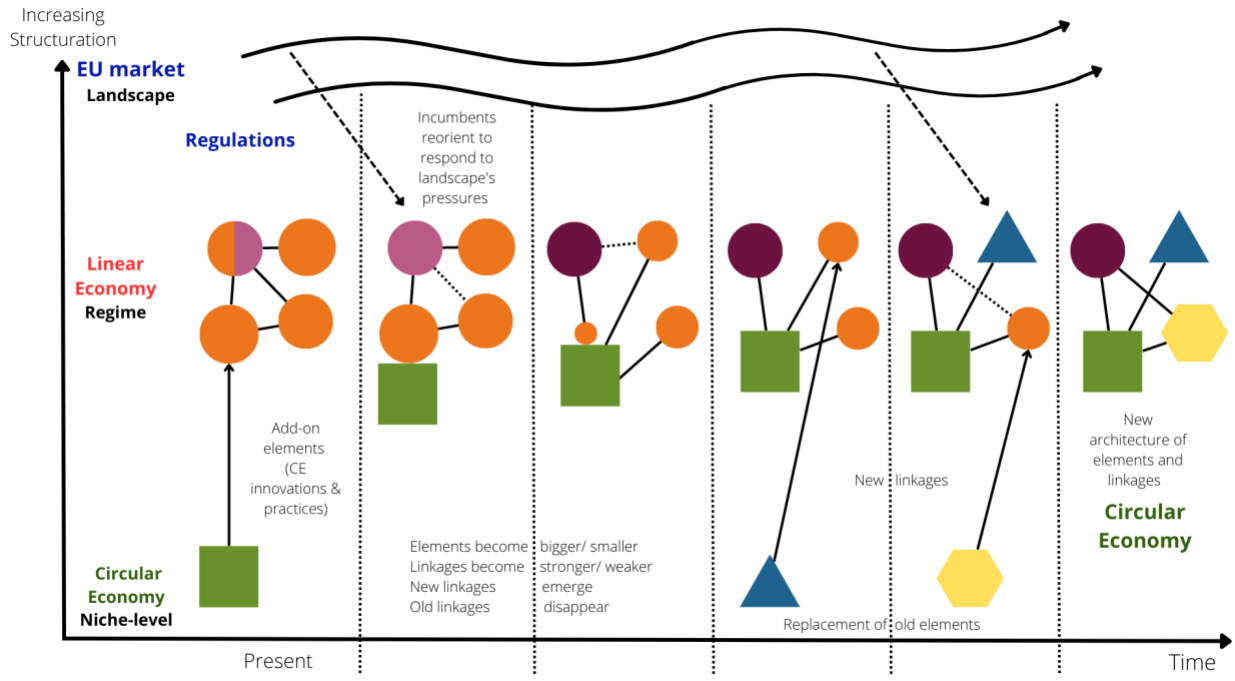

Figure 12: Revised Conceptual Framework

6 CONCLUSIONS

6.1 Main Findings

From the empirical data gathered and analyzed, the core findings of this study, in response to the research questions, are as follows:

a. The manner in which companies perceive and implement CE is heavily context dependent. In other words, companies are more concerned with the practical applications of CE in their operations, possibly due to their introduction to the concept through legislative measures rather than scholarly sources. This aligns with previous research, highlighting that companies adopt CE strategies to improve resource efficiency, reduce waste, and enhance competitiveness. The companies in this study develop tailored performance indicators relevant to their specific goals and objectives, as opposed to adhering to standardized metrics. This finding reflects the practical and context-specific nature of CE implementation among private enterprises and underscores the need for customized performance indicators. Furthermore, the extent to which companies prioritize CE principles when collaborating with partners and

subcontractors varies. Some firms place a stronger emphasis on environmental, social, and governance (ESG) and corporate social responsibility (CSR) criteria, while others consider CE as a factor but not a deal-breaker.

b. The Finnish government's policy approach to achieving a CE is mainly a combination of interactive network governance and market model approaches. The government is responsible for defining CE targets, but companies and customers are seen as the main actors responsible for execution, which aligns with the market model policy approach. However, the effectiveness of the interactive network governance approach remains uncertain, as not all companies report active engagement in government-led efforts. The Finnish government also enacts laws to set the regulatory framework for the CE, but this approach is less emphasized. Finland's policy program for the CE focuses mainly on niche stimulation and acceleration, with limited policies dedicated to opening up and unlocking regimes. The nature of the CE movement in Finland can be described as 'progressive system change,' characterized by incremental changes over time. However, stronger measures may need to be introduced to achieve ambitious CE goals, as the current policy landscape appears weak and inconsistent.

c. Digitalization plays a pivotal role in facilitating the successful operation of the companies interviewed, most of which are young start-ups with circular business models that heavily rely on digital technologies. In fact, these start-ups could be regarded as digital economy enterprises embracing circularity due to the scale and nature of their operations. Digitalization not only benefits innovative young enterprises but also supports established companies transitioning from linear to circular models. In addition to digital technologies, pioneering CE companies may also explore other technological advancements, such as biotechnology, to redesign existing materials or develop new ones to achieve their CE objectives. In the long term, it is essential for all CE companies in Finland to consider integrating digital technologies more comprehensively into their operations. This is particularly relevant as the 'twin transition' towards digitalization and circularity is a key target for both the European

Union and the Finnish government. Furthermore, Finland's position as a leader in digital performance presents a significant advantage in facilitating this transition.

6.2 Implications for International Business

While the focus of this thesis is on the Finnish CE landscape, the findings could have broader implications for other European countries. Notably, many of the companies participating in the empirical research have an international presence, with several expanding rapidly, which suggests that the experiences of these companies could be relevant beyond the Finnish context. Moreover, these findings could be particularly relevant for EU member states with similar levels of digital performance as indicated by the Digital Economy and Society Index (DESI). Given the EU's objective of promoting digitalization across member states, understanding the relationship between digitalization and CE could provide insights for firms in other countries on how to leverage their digital infrastructure to accelerate CE development.

6.3 Limitations

The study is not without its limitations. Firstly, the sample size of the study is relatively small, with only seven interviews conducted with respondents from seven circular economy firms. Furthermore, the majority of the sample comprises small to micro-sized startups, with only one long-established and large-sized company. As a result, the findings of this study may not be representative of all circular economy firms in Finland. Additionally, the response rate for the follow-up survey on digital performance was relatively low, with only five firms completing the survey. Furthermore, it should be noted that four out of the five survey respondents selected the NI option at least once, indicating the difficulty some firms may have had in accessing or retrieving the necessary information to answer the survey questions accurately. This further underscores the potential impact of the NI option on the accuracy of the DII-based evaluation of the firms' digital performance. Therefore, the conclusions drawn from this study should be interpreted with caution, and further research with a larger and more diverse sample of circular economy firms in Finland would be beneficial to develop a more comprehensive understanding of the topic.

6.4 Suggestions for Further Research

As a qualitative study, the present research could benefit from further exploration of its themes in a quantitative format. An avenue for future research could entail administering a survey employing the Digital Intensity Index (DII) to gauge the degree of digitalization present in Finnish companies implementing circular economy practices. By amassing a sufficiently large sample size, statistical analyses may be employed to verify the positive association between digitalization and CE practices.

In addition to exploring firms' perspectives, future research should prioritize examining individual consumer perspectives. Empirical data gleaned from this study underscores the vital role of consumers in facilitating a CE. Given the lack of existing research on customer perspectives in the EU, and particularly Finland, investigating this aspect would be of great value. Such research would likely generate a more comprehensive understanding of the complex interplay of factors influencing the development and implementation of circular economy initiatives, ultimately contributing to a more holistic approach to policymaking and corporate strategies in support of a sustainable and circular economic model.

REFERENCE LIST

Accenture (2014) *Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth.* Dublin, Ireland: Accenture

Alashhab, Z.R., Anbar, M., Singh, M.M., Leau, Y., Al-Sai, Z.A. & Alhayja'a, S.A. (2021) 'Impact of coronavirus pandemic crisis on technologies and cloud computing applications', *Journal of Electronic Science and Technology*; 19(1). Retrieved from: ScienceDirect

Alcalde-Calonge, A., Saez-Martinez, F. J., & Ruiz-Palomino, P. (2022) 'Evolution of research on circular economy and related trends and topics. A thirteen-year review', *Ecological Informatics*; 70. Retrieved from: ScienceDirect

Alhawari, O., Awan, U., Bhutta, M.K.S. & Ülkü, M.A. (2021) 'Insights from Circular Economy Literature: A Review of Extant Definitions and Unravelling Paths to Future Research', *Sustainability*; 13(2): 859. Retrieved from: MDPI

Alizadeh, M., Kashef, A., Wang, Y., Wang, J., Kremer, G. E. O. & Ma, J. (2023) 'Circular Economy conceptualization using text mining analysis', Sustainable Production and Consumption; 35: 643-654. Retrieved from: ScienceDirect

Anderson, R. (2007) 'Thematic Content Analysis (TCA): Descriptive Presentation of Qualitative Data' [Online]. Available from: http://rosemarieanderson.com/wp-content/uploads/2014/08/ThematicContentAnalysis.pdf

Antikainen, M., & Valkokari, K. (2016) A Framework for Sustainable Circular Business Model Innovation. Technology Innovation Management Review, 6(7), 5-12.

Antikainen, M., Uusitalo, T. & Kivikytö-Reponen, P. (2018) ' Digitalisation as an Enabler of Circular Economy', *Procedia CIRP*; 73: 45-49. Retrieved from: ScienceDirect

Bartl, A. (2020) 'The Circular Economy Package of the European Union: Are New Paths Being Taken or Is It an Old Story?', *Detritus - Multidisciplinary Journal for Waste Resources & Residues*; 12: 12-17 [Accessed on 29 January 2023].

Bocken, N.M.P., de Pauw, I., Bakker, C. & van der Grinten, B. (2015) 'Product design and business model strategies for a circular economy', *Journal of Industrial and Production Engineering*; 33: 308-320. Retrieved from: Taylor & Francis Online

Boulding, K. (1966) 'The Economics of the Coming Spaceship Earth' In: Jarrett, H. (1966) (ed.) *Environmental Quality in a Growing Economy.* Baltimore: RFF Press

Brundtland, G. (1987). Report of the World Commission on Environment and Development: Our Common Future. United Nations General Assembly document A/42/427.

Chauhan, C., Parida, V. & Dihr, A (2022) 'Linking circular economy and digitalization technologies: A systematic literature review of past achievements and future promises', *Technological Forecasting and Social* Change; 177. Retrieved from: ScienceDirect [Accessed on 01 December 2022].

Circular Economy Competence Center. Retrieved from: https://www.circularfinland.fi/competence-center/

Circular Economy Promotion Law of the People's Republic of China (2009) Available from: https://www.lawinfochina.com/display.aspx?id=7025&lib=law

Corvellec, H., Stowell, A. & Johansson, N. (2021) 'Critiques of the circular economy', *Journal of Industrial Ecology*; 26(2): 421-432. Retrieved from: Wiley Online Library

Creswell, J.W. (2009) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* California: SAGE Publications

Del Giudice, M., Chierici, R., Mazzucchelli, A. & Fiano, F. (2021) 'Supply chain management in the era of circular economy: the moderating effect of big data', *The International Journal of Logistics Management*; 32(2): 337-356

Deloitte (2018) *Breaking blockchain open.* California: Deloitte Development

Deloitte (2022) *The App Economy in Europe*. Paris, France: Deloitte France.

Diaz-Garcia, C., Gonzalez-Moreno, A., & Saez-Martínez, F.J. (2020) 'Circular economy and SMEs: insights and EU situation included in Laveren.' *Sustainable Entrepreneurship and Entrepreneurial Ecosystems*. UK: Edward Elgar Publishing, pp. 12–28.

Ellen MacArthur Foundation (2013) 'Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition' [Online] Available from: [Accessed on 10 February 2023]

Ellen MacArthur Foundation (2013) *Towards the circular economy: Economic and business rationale for an accelerated transition.* Available from: https://ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an

Ellen MacArthur Foundation (2015) *Towards a circular economy: Business rationale for an accelerated transition.* Available from: https://ellenmacarthurfoundation.org/towards-a-circular-economy-business-rationale-for-an-accelerated-transition

Erkman, S. (1997) 'Industrial ecology: An historical View', *Journal of Cleaner Production*; 5 (1-2): 1-10. Retrieved from: ScienceDirect

EU: European Economic and Social Committee (2017) *Monitoring framework for the circular economy (communication)*. Brussels: EESC [Accessed on 29 January 2023].

EU: European Foundation for the Improvement of Living and Working Conditions (2020) *Living, working and COVID-19.* Dublin: Eurofound

EU: Eurostat (2022) *How digitalised are the EU's enterprises?* Luxembourg: Eurostat

European Commission (2020). Circular economy action plan. Retrieved from: https://ec.europa.eu/environment/circular-economy/

European Commission (2022) *Digital Economy and Society Index (DESI) 2022: Finland*. Available from: https://digital-strategy.ec.europa.eu/en/policies/countries-digitisation-performance [Accessed on 07 January 2023].

European Commission (n.d.) *European blockchain regulatory sandbox for Distributed Ledger Technologies*. Available from: https://ec.europa.eu/digital-building-blocks/wikis/display/EBSI/Sandbox+Project

European Union (2008) 'Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives'. Retrieved from https://www.legislation.gov.uk/eudr/2008/98/contents

Eurostat (2022) *Circular economy – material flows.* Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Circular_economy_-_material_flows#Circularity_rate_.E2.80.93_methodology [Accessed on 29 January 2023].

Finland: *Government Resolution on the Strategic Programme for Circular Economy 2021*.

Finland: Statistics Finland (2020) *Indicators for the circular economy business 2020.* Helsinki, Finland: Statistics Finland

Finnish Government (2019) 'Government Programme of Prime Minister Antti Rinne'. Retrieved from https://valtioneuvosto.fi/en/rinne/government-programme

Frosch, R. A. & Gallopoulos, N. E. (1989) 'Strategies for Manufacturing', *Scientific American*; 261 (3): 144-153. Retrieved from: JSTOR

Fura, B., Stec, M. & Mis, T. (2020) ‘Statistical Evaluation of the Level of Development of Circular Economy in European Union Member Countries’, *Energies*; 13(23). Retrieved from: MDPI

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy, 31(8-9), 1257-1274.

Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. Technological Forecasting and Social Change, 72(6), 681-696.

Geels, F. W. (2014). Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. Theory, Culture & Society, 31(5), 21-40.

Geels, F. W., Berkhout, F., & van Vuuren, D. P. (2016). Bridging analytical approaches for low-carbon transitions. Nature Climate Change, 6(6), 576-583.

Geels, F. W., Sovacool, B. K., Schwanen, T., & Sorrell, S. (2019). Sociotechnical transitions for deep decarbonization. Science, 366(6463), 49-55.

Geels, F.W. (2004) ‘From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory’, *Research Policy*; 33(6-7): 879-920. Retrieved from: ScienceDirect

Geels, F.W. (2019) ‘Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study’, *Research Policy*; 31(8-9): 1257-1274. Retrieved from: ScienceDirect

Geels, F.W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., Neukirch, M. & Wassermann, S. (2016) ‘The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-

carbon electricity transitions (1990–2014)', *Research Policy*; 45(4): 896-913. Retrieved from: ScienceDirect

Geels, F.W., McMeekin, A., Mylan, J. & Southerton, D. (2015) 'A critical appraisal of Sustainable Consumption and Production research: The reformist, revolutionary and reconfiguration positions'. *Global Environmental Change*; 34: 1-12. Retrieved from: ScienceDirect

Genovese, A., Acquaye, A. A., Figueroa, A., & Koh, S. C. L. (2017). Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications. Omega, 66, 344-357.

Ghisellini, P & Ulgiati, S. (2016) 'A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems', *Journal of Cleaner Production*; 114: 11-32. Retrieved from: ScienceDirect [Accessed on 29 January 2023].

Ghoreishi, M. & Happonen, A. (2020) 'New promises AI brings into circular economy accelerated product design: a review on supporting literature', *E3S Web Conf.*; 158. Retrieved from: EDP Sciences

Ghose, R. (2019) 'What Finland's Remote Work Culture Can Teach Your Business' [Weblog]. *DistantJob Blog*; Canada, 24 September. Available from: https://distantjob.com/blog/what-finlands-remote-work-culture-can-teach-your-business/

Graham-Rowe, E., Jessop, D.C. & Sparks, P. (2014) 'Identifying motivations and barriers to minimising household food waste', *Resources, Conservation and Recycling*; 84: 15-23. Retrieved from: ScienceDirect

Helsinki: Ympäristöministeriö [Accessed on 29 January 2023].

Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: Radical social transformation in a resource-scarce world. Futures, 82, 15-25.

Iankova, S., Davies, I., Archer-Brown, C., Marder, B. & Yau, A. (2019) 'A comparison of social media marketing between B2B, B2C and mixed business models', *Industrial Marketing Management*; 81: 169-179. Retrieved from: ScienceDirect

Interest Groups in Policy Making in Finland', *Scandinavian Political Studies*; 41(4): 239-262. [Online]. Available from: https://helda.helsinki.fi/bitstream/handle/10138/323945/Vesa_et_al_2018_The_Involvement_of_Interest_Groups_in_Policy_Making_in_Finland_Author_accepted_version.pdf?sequence=1

IPCC (2014) Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: IPCC.

Jahn, D. (2014) 'Changing of the guard: trends in corporatist arrangements in 42 highly industrialized societies from 1960 to 2010', *Socio-Economic Review*; 14(1): 47-71. Retrieved from: Oxford Academic

Kirchherr, J., Reike, D. & Hekkert, M. (2017) 'Conceptualizing the circular economy: An analysis of 114 definitions.' *Resources, Conversation & Recycling* [Onine] 127: 221-232. Retrieved from: ScienceDirect [Accessed on 01 December 2022].

Kivimaa, P. & Kern, F. (2016) 'Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions', *Research Policy*; 45(1): 205-217. Retrieved from: ScienceDirect

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018) Circular Economy: The Concept and its Limitations. Ecological Economics, 143, 37-46.

Korhonen, J., Nuur, C., Feldmann, A. & Birkie, S.E. (2018) ‘Circular economy as an essentially contested concept’, *Journal of Cleaner Production*; 175: 544-552. Retrieved from: ScienceDirect

Korsunova, A. & Vainio, A. (2021) ‘Understanding circular economy in everyday life: Perceptions of young adults in the Finnish context’ Sustainable Production and Consumption [Online] 26: 759-769. Retrieved from: ScienceDirect [Accessed on 01 December 2022].

Kottmeyer, B. (2021) ‘Digitisation and Sustainable Development: The Opportunities and Risks of Using Digital Technologies for the Implementation of a Circular Economy’, *Journal of Entrepreneurship and Innovation in Emerging Economies*; 7(1). Retrieved from: Sage Journals

Laroche, M., Habibi, M.R. & Richard, M. (2013) ‘To be or not to be in social media: How brand loyalty is affected by social media?, *International Journal of Information Management*; 33(1): 76-82. Retrieved from: ScienceDirect

Lazarevic, D., Salo, H. & Kautto, P. (2022) ’Circular economy policies and their transformative outcomes: The transformative intent of Finland's strategic policy programme’, *Journal of Cleaner Production*; 379(2) Retrieved from: ScienceDirect

Lima, L.R., Gutierrez, R.F. & Cruz, S.A. ’Challenges in the context of single-use plastics and bioplastics in Brazil: A legislative review, *Waste Management & Research: The Journal for a Sustainable Circular Economy*; 40(7). Retrieved from: Sage Journals

Lowe, E. A. & Evans, L. K. (1995) ‘Industrial ecology and industrial ecosystems’, *Journal of Cleaner Production*; 3 (1-2): 47-53. Retrieved from: ScienceDirect

Ludeke-Freund, F., Gold, S. & Bocken, N. (2019). ‘A Review and Typology of Circular Economy Business Model Patterns’, *Journal of Industrial Ecology*; 23: 36-61. Retrieved from: Wiley Online Library

Lund University CIRCLE Centre for Innovation Research (2022) *Great expectations: the promises and limits of innovation policy in addressing societal challenges.* Lund, Sweden: CIRCLE

Marjamaa, M., Salminen, H., Kujala, J., Tapaninaho, R., & Heikkinen, A. (2021). A Sustainable Circular Economy: Exploring Stakeholder Interests in Finland*. South Asian Journal of Business and Management Cases*; 10(1): 50–62. Retrieved from: Sage Journals [Accessed on 01 December 2022].

Martin, S., Weitz, K.A., Cushman, R.A., Sharma, A., Lindrooth, R.C. & Moran, S.R. (1996) 'Eco-Industrial Parks: A Case Study and Analysis of Economic, Environmental, Technical, and Regulatory Issues.', *Institute of Portland Metropolitan Studies* [Online]. Available from: https://pdxscholar.library.pdx.edu/metropolitianstudies/110/

McCormick, K. & Kautto, N. (2013) 'The Bioeconomy in Europe: An Overview', *Sustainability*; 5(6). Retrieved from: MDPI

Mhatre, P., Panchal, R., Singh, A. & Bibyan, S. (2020). 'A Systematic Literature Review on the Circular Economy Initiatives in the European Union'. *Sustainable Production and Consumption*. 26: 10.

Ministry of Economic Affairs and Employment of Finland *(n.d.) Digital Finland framework: Framework for turning digital transformation to solutions to grand challenges.* Available from: https://www.businessfinland.fi/globalassets/julkaisut/digital-finland-framework.pdf [Accessed on 07 January 2023].

Montalvo, C., Karanikolova, K. & Lopez, F.J.D. (2021) 'Green and digital twin transitions: process of structuration and evolution of circular economy and industrial digitalisation' [Online]. Available from: https://circulareconomy.europa.eu/platform/sites/default/files/tfsc_twintransitions_preprint_cm_kk_fdl_14.06.21_1.pdf

Moraga, G., Huysveld, S., Mathieux, F., Blengini, G., Alaerts, L., Van Acker, K., de Meester, S. & Dewulf, J. (2019) 'Circular economy indicators: What do they measure?', *Resources, Conservation and Recycling*; 146: 452-461. Retrieved from: ScienceDirect [Accessed on 29 January 2023].

Ness, D. (2008). 'Sustainable urban infrastructure in China: towards a factor 10 improvement in resource productivity through integrated infrastructure system', *International Journal of Sustainable Development & World Ecology*; 15 (4): 288 – 301. Retrieved from: Taylor & Francis Online

Nguyen, N. & Le, H. (2022) 'Making the circular economy digital or the digital economy circular? Empirical evidence from the European region', *Technology in Society*; 70. Retrieved from: ScienceDirect

Nordic Circular Hotspot (n.d.) *Accelerating the transition to a circular economy in the Nordics*. Available from: https://nordiccircularhotspot.org/

Nordic Countries: Nordic Co-operation (n.d.) *Welcome to Nordic Co-operation.* Copenhagen: Nordic Council

Notaro, S., Lovera, E. & Paletto, A. (2022) 'Consumers' preferences for bioplastic products: A discrete choice experiment with a focus on purchase drivers', *Journal of Cleaner Production*; 330. Retrieved from: ScienceDirect

OECD (2018). OECD Economic Surveys: Finland 2018. Paris: OECD Publishing. https://doi.org/10.1787/eco_surveys-fin-2018-en

Pagoropoulos, A., Pigosso, D.C.A & McAloone, T.C. (2017) 'The Emergent Role of Digital Technologies in the Circular Economy: A Review', *Procedia CIRP*; 64: 19-24. Retrieved from: ScienceDirect

Pallesen, T. (2006) ‘Scandinavian Corporatism in a Trans-Atlantic Comparative Perspective’, *Scandinavian Political Studies*; 29(2): 131-145. Retrieved from: Wiley Online Library

Parizeau, K., von Massow, M. & Martin, R. (2015) ‘Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario’, *Waste Management*; 35: 207-217. Retrieved from: ScienceDirect

Pascale, A., Arbolino, R., Depczynska, K., Limosani, M. & Ioppolo, G. (2021) ‘A systematic review for measuring circular economy: The 61 indicators’, *Journal of Cleaner Production*; 281. Retrieved from: ScienceDirect [Accessed on 29 January 2023].

Past earth overshoot days (2022) Available from: https://www.overshootday.org/newsroom/past-earth-overshoot-days/

Pearce, D.W. & Turner, R.K. (1991) ‘Economics of natural resources and the environment’, *American Journal of Agricultural Economics*; 73(1): 227-228 Retrieved from: ResearchGate [Accessed on 29 January 2023].

Pesce, M., Tamai, I., Guo, D., Critto, A., Brombal, D., Wang, X., Cheng, H. & Marcomini, A. (2020) ‘Circular Economy in China: Translating Principles into Practice’, *Sustainability*; 12(3): 832. Retrieved from: MDPI

Rajput, S. & Singh, S. (2019) ‘Connecting circular economy and industry 4.0’ *International Journal of Information Management* [Online] 49: 98-113. Retrieved from: ScienceDirect [Accessed on 01 December 2022].

Reike, D., Vermeulen, W. & Witjes, S. (2018) ‘The circular economy: New or Refurbished as CE 3.0? – Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options’, *Resources, Conservation and Recycling*; 135: 246-264 Retrieved from: ScienceDirect [Accessed on 29 January 2023].

Repo, P., Anttonen, M., Mykkänen, J. & Lammi, M. (2012) 'Lack of Congruence between European Citizen Perspectives and Policies on Circular Economy', *European Journal of Sustainable Development*; 7(1). [Online]. Available from: http://ecsdev.org/ojs/index.php/ejsd/article/view/618

Richter, B. (2017) 'Knowledge and perception of food waste among German consumers', *Journal of Cleaner Production*; 166(10): 641-648. Retrieved from: ScienceDirect

Rizos, V., Behrens, A., Van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papadelis, S., Hirschnitz-Garvers, M. & Topi, C. (2016) 'Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers', *Sustainability*; 8(11): 1212. Retrieved from: MDPI

Roberts, C. & Geels, F.W. (2019) 'Conditions for politically accelerated transitions: Historical institutionalism, the multi-level perspective, and two historical case studies in transport and agriculture', *Technological Forecasting and Social Change*; 140: 221-240. Retrieved from: ScienceDirect

Robinson, O.C. (2014) 'Sampling in Interview-Based Qualitative Research: A Theoretical and Practical Guide', *Qualitative Research in Psychology*; 11(1). Retrieved from: Taylor & Francis Online

Saavedra, Y., Iritani, D. R., Pavan, A. L. R. & Ometto, A. R. (2018) 'Theoretical contribution of industrial ecology to circular economy', *Journal of Cleaner Production*; 170: 1514-1522. Retrieved from: ScienceDirect

Sakai, S., Yoshida, H., Takigami, H., Takahashi, S., Tomoda, K., Peeler, M., Wejchert, J., Schmid-Unterseh, T., Douvan, A., Hathaway, R., Hylander, L., Fischer, C., Oh, G., Jinhui, L., & Ngo, C. (2011) 'International comparative study of 3R and waste management policy developments', *Journal of Material Cycles and Waste Management*; 13: 86-102 Retrieved from: Springer Link

Singh, R.P., Haleem, A., Javaid, M., Kataria, R. & Singhal, S. (2021) 'Cloud Computing in Solving Problems of COVID-19 Pandemic', *Journal of Industrial Integration and Management*; 6(2): 209-219. Retrieved from: World Scientific

Sitra (2018) *Leading the cycle: Finnish road map to a circular economy 2016-2025*. Helsinki, Finland: Sitra.

Sitra (2018) *The circular economy: a powerful force for climate mitigation*. Helsinki, Finland: Sitra.

Sitra (2020) *How to create a national circular economy road map*. Helsinki, Finland: Sitra.

Sitra (2022) *Sustainable growth with circular economy business models. Helsinki, Finland: Sitra*

Smith, A. & Raven, R. (2012) 'What is protective space? Reconsidering niches in transitions to sustainability', *Research Policy*; 41: 1025-1036. Retrieved from: ScienceDirect

Statista (2021) *Annual production of plastics worldwide from 1950 to 2021*. Hamburg, Germany: Statista.

Sullivan, J. & Hussain, B. 'How technology unlocks new value from the circular economy', *GreenBiz* [Online]. Available from: https://www.greenbiz.com/article/how-technology-unlocks-new-value-circular-economy

Tan, E.C.D. & Lamers, P. (2021) 'Circular Bioeconomy Concepts—A Perspective', *Frontiers in Sustainability*; 2. [Online]. Available from: https://www.frontiersin.org/articles/10.3389/frsus.2021.701509/full

Telaketju (n.d.) *About Telaketju.* Available from: https://telaketju.turkuamk.fi/en/about-telaketju/

The Australia Institute (2009) *What a waste: An analysis of household expenditure on food*. Canberra, Australia: The Australian Institute.

Tkachuk, V.I., Zinovchuk, V.V., Tarasovych, L.V. & Yaremova, M.I. (2020) 'A Significance of Digital Marketing for Promoting Bio-economy in Ukrainian Economy', *International Journal of Advanced Science and Technology*; 29(6): 1043-1049 [Online]. Available from: http://sersc.org/journals/index.php/IJAST/article/view/9171

UNEP (2019). Global Resources Outlook 2019: Natural Resources for the Future We Want. Nairobi, Kenya: United Nations Environment Programme.

United Nations (n.d.) *Sustainable Development Goals - 17 Goals to Transform Our World*. Nairobi: United Nations

United Nations: United Nations Environment Programme (2022) *Plastic pollution science.* Nairobi: United Nations Environment Programme.

Vesa, J., Gronow, A. & Ylä-Anttila, T. (2020) 'The quiet opposition: How the pro-economy lobby influences climate policy', *Global Environmental Change*; 63. Retrieved from: ScienceDirect

Vesa, J., Kantola, A. & Binderkrantz, A.S. (2018) 'A Stronghold of Routine Corporatism? The Involvement of Interest Groups in Policy Making in Finland', *Scandinavian Political Studies*; 41(4): 239-262. Retrieved from: Wiley Online Library

Woldeyes, T., Muffatto, M. & Ferrati, F. (2022) 'Emerging Business Models for Circular Economy: A Systematic Literature Review.' In: Proceedings of the 17th European Conference on Innovation and Entrepreneurship; Cyprus: 15-16 September. UK: Academic Conferences International Limited. pp. 599-607.

Wrap (2007) *Food Behaviour Consumer Research: Quantitative Phase*. Banbury, Englang: Wrap

Wrap (2007) *We don't waste food – a household survey (2006).* Banbury, England: Wrap.

Wynn, M. & Jones, P. (2022) 'Digital Technology Deployment and the Circular Economy', *Sustainability*; 14(15): 9077. Retrieved from: MDPI

APPENDICES

Appendix A: Interview Questions

Company:

Respondent name:

Respondent role:

1. **Perception of circular economy**
   a. How do you define circular economy?
      Follow-up question: Do you adapt this definition from an external source?
   b. How is circular economy different from sustainable development?
   c. The 'Rs frameworks' (3Rs: reduce, reuse, recycle) and 'System perspective' are repeatedly featured in CE literature. Have you heard of any of the concepts?

2. **Circular Economy Ecosystem**
   a. Is your company aware of CE initiatives by the EU and the Finnish goverment?
      Follow-up question: *Can you name some of them? Is your company a member/ participant of these initiatives?*
   b. Does your company receive funding from any of these initiatives?
   c. What roles do you think the goverment, companies, and consumers play in promoting CE?

3. **Key Capabilities for Circularity**
   a. What quantifiable metrics do you use to measure CE progress?
   b. Do you provide employees with training to develop CE-related skills?
   c. Do you prioritize partners and subcontractors with CE in their agenda?
   d. What are the challenges that you have regarding CE implementation?

e. Do you utilize sharing platforms, either as a provider or a user, to maximize the utilization rate of products and resources?

f. Do you find and apply new digital technologies into your operation to achieve CE goals?

Follow-up question: Can you name some examples?

4. Digitalization

a. Are these digital solutions provided by an internal department or outsourced?

Follow-up question: Is your outsourcing partner also based in Finland?

b. Do you provide employees with digital training?

c. Do you offer employees with opportunities to work remotely?

d. Do you set a goal to become more digitalized?

Appendix B: Survey Questions

Survey on the digital intensity of Finnish companies with successful circular economy application

Question 1:

Dear respondent,

The following survey is a part of the bachelor's thesis by Vu Trang, a student at Aalto University School of Business. The thesis is titled 'Facilitating a digitalization-led circular economy in Finland'. The survey aims to examine the digital intensity of Finnish enterprises successfully incorporating circular economy principles into their business operation. Participation in this survey is voluntary. All answers will be used solely for scholarly purposes.

If you have any questions or concerns about this survey, please get in touch with Vu Trang at vu.trang@aalto.fi.

This survey should take 10 minutes to complete. Your participation is highly appreciated. *

I have read and I understand the terms of this survey.

Question 2 to 5:

The statements below are adopted from the Digital Intensity Index v3 (2021) by Eurostat to measure the digital intensity of EU enterprises. Please select the option that applies to your company. *

	Agree	Disagree	No Information
More than 50% of our employees use computers with Internet access for business purposes			

We have an enterprise resource planning (ERP) software package to share information between different functional areas			
Our maximum contracted download speed of the fastest fixed-line internet connection is at least 30 Mb/s			
We use Internet-of-things (IoT) in our operation			
We use artificial intelligence (AI) technology			
We buy cloud computing (CC) services used over the Internet			
We buy sophisticated or intermediate CC services			
We use one social media platform			
We use two or more social media platforms			
We have a customer relationship management system			
We have web sale accounting for more than 1% of the total turnover and B2C web sales for more than 10% of the web sales			
We have e-commerce sales of at least 1% turnover			

Question 6: What digital technologies does your company adopt and utilize?*

You can choose more than one option. If the digital solution(s) that you adopt cannot be found from the list, please specify in 'Other(s)'. If you utilize no digital solution, please choose 'None'.

Artificial Intelligence & Machine learning

Automatic identification (optical codes/ radio frequency identification/ chemical markers)

Big data analytics

Blockchain/ Distributed ledger technologies (DLT)

Cloud Computing

Digital fabrication/ Digital-twin/ 3-D Printing

Internet of things (IoT)

Product Life Cycle Management (PLCM) software

Robotics

Social media

Mobile application

Other(s)

None

Question 7: Who is responsible for these digital solutions?

Internal IT department

Outsourcing partners

Question 8: In which year was your company founded? *

Question 9: What is the size of your company? *

Micro-sized business (Less than 10 employees)

Small-sized business (10 - 49 employees)

Medium-sized business (50 - 249 employees)

Large-sized business (More than 250 employees)

Appendix C: Digital Intensity Index

Source: Eurostat, 2022

DIGITAL INTENSITY INDEX V3 (2021)

The index is derived from the following features in:

		2021
DI3_Index	0-12	Give one point for each of the following 12 conditions, if true:
		Enterprises where more than 50% of the persons employed used computers with access to the internet for business purposes
		Have ERP software package to share information between different functional areas
		The maximum contracted download speed of the fastest fixed line internet connection is at least 30 Mb/s
		Enterprises where web sales were more than 1% of the total turnover and B2C web sales more than 10% of the web sales
		Use any IoT
		Use any social media
		Have CRM
		Buy sophisticated or intermediate CC services (2021)
		Use any AI technology
		Buy CC services used over the internet
		Enterprises with e-commerce sales of at least 1% turnover
		Use two or more social media

E_DI3_VLO	Enterprise has very low digital intensity index v3	Count of enterprises with points between 0 and 3
E_DI3_LO	Enterprise has low digital intensity index v3	Count of enterprises with points between 4 and 6
E_DI3_HI	Enterprise has high digital intensity index v3	Count of enterprises with points between 7 and 9
E_DI3_VHI	Enterprise has very high digital intensity index v3	Count of enterprises with points between 10 and 12

Appendix D: Transformative outcomes framework

Source: Lazarevic et al., 2022

Macro-process	Transformative Outcome	Contribution	Examples/Strategies
1. Promoting and nurturing niches	Shielding	Offering protection for niche experiments and normalising protection measures across different dimensions (e.g., STI, market, cultural)	R&D subsidies, taxes, purchasing, voluntary agreements, regulation, information campaigns, network-building, activism
	Learning	Inducing first and second order cognitive process of knowing, understanding and reflecting	Incorporating different forms of knowledge and aspects of sustainability. Organising opportunities for challenging assumptions
	Networking	Creating high-quality opportunities for collaboration between actors and strengthen their networks	Joint activities, enhancing mobilizing power, mutual trust and coordination. (e.g., transition arenas)
	Navigating expectations	Creating spaces for articulating expectations around societal challenges and appraising these expectations to enhance their credibility, quality and stability collective perceptions about landscape pressures of diverse groups of regime actors	Allowing a diversity of actors to voice their expectations (e.g., futuring processes). Developing credible expectations (e.g., transition arenas)
2. Expanding and mainstreaming niches	Upscaling	Increasing the adoption by users of the new emerging system, new user preferences, technologies, policy measures, industry strategies and cultural meanings	A user club or marketing campaigns
	Replicating	Facilitating the replication of specific niche	Funding programme for regional replicatiion of experiments

Macro-process	Transformative Outcome	Contribution	Examples/Strategies
		experiments in other contexts	
	Circulating	Identifying and promoting the circulation of ideas, people, and technologies	Continuous circulation between niches, e.g., via an intermediary actor
	Institutionalizing	Mainstreaming niche practices and rules among existing and new niche actors;	Creating a handbook, a certification scheme or standards
3. Opening up and unlocking regimes	De-aligning and destabilising	Facilitating the development of disruptive policy frameworks and governance arrangements that challenge existing systems	Developing phase-out policies, mobilizing social protests
	Unlearning and deep learning in regimes	Facilitating unlearning and deep learning among regime actors, helping them reassess the regime rules and question existing behaviours, belief, values and norms	Organising a policy lab to discuss policy barriers
	Strengthening regime-niche interactions	Creating linkages between niche and regime actors, and their ideas and resources across multiple niches	Developing new impact investment tools to invest in niche activities
	Changing perceptions of landscape pressures	Facilitating processes to challenge individual and collective perceptions about landscape pressures	Foresight activities with regime actors
4. Repercussions of regime destabilisation	*Reducing socio-economic impact*	Addressing the socio-economic impacts resulting from systemic change	Payments for industry for the closure of plants, provision of financial and educational support for managing structural unemployment and skill

Macro-process	Transformative Outcome	Contribution	Examples/Strategies
			mismatchs, regional development policies
	Societal deliberation	Facilitating the participation and inclusion of affected actors in planning and decision-making processes	Coproduction of pathways with affected communities, regions and industries; community consultation
5. Provide coordination to multi regime interaction	*Horizontal coordination*	Coordinating and aligning policy processes across multiple policy domains and supporting positive reinforcing linkages	Cross-sectoral roadmaps
	Vertical coordination	Coordinating and aligning policy processes across governance levels	Strategies and visions that interact at national, regional and local scales
6. Tilt the landscape	*Common directionality*	Altering the broader framework conditions by negotiating a common directionality of change for locally bounded socio-technical systems	International agreement-based mechanisms; Internationally agreed goals

Appendix E: Reformulated socio-technical transition pathways

Table: Reformulated and differentiated transition pathways (Geels et al., 2016)

Transition pathway	Actors	Technologies	Rules and institutions
(1) Substitution	New firms struggle against incumbent firms, leading to overthrow Different kinds of 'new entrants' (e.g. citizens, communities, social movement actors, incumbents from different sectors) replace incumbents	Radical innovation(s) substituting existing technology	Limited institutional change, implying that niche-innovation needs to compete in existing selection environment ('fit-and-conform') ('Incremental adjustment', 'Layering') Creation of new rules and institutions to suit the niche-innovation ('stretch-and-transform') ('Disruption', 'Displacement')
(2) Transformation	Incumbents reorient incrementally by adjusting search routines and procedures	Incremental improvement in existing technologies (leading to major performance enhancement over long time period). Incorporation of symbiotic niche-innovations and add-ons (competence-adding, creative accumulation)	Limited institutional change ('Layering')
	Incumbents reorient substantially, to radically new technology or, even more deeply, to new	Reorientation towards new technologies: (a) partial reorientation (diversification) with incumbents developing	Substantial change in institutions ('Conversion', 'Displacement')

Transition pathway	Actors	Technologies	Rules and institutions
	beliefs, mission, and business model	both old and new technologies (b) full reorientation, leading to technical substitution	
(3) Reconfiguration	New alliances between incumbents and new entrants	From initial add-ons to new combinations between new and existing technologies; knock-on effects and innovation cascades that change system architecture.	From limited institutional change (‘Layering’) to more substantial change, including operational principles (‘Drift’, ‘Conversion’)
(4) De-alignment and re-alignment	Incumbents collapse because of landscape pressure, creating opportunities for new entrants	Decline of old technologies creates space for several innovations which compete with one another	Institutions are disrupted by shocks and replaced, possibly after prolonged uncertainty (‘Disruption’)