# DIGITAL TRANSFORMATION AND BUSINESS SUSTAINABILITY

## From Theory to Practice

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# 3

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## Evidence from Multiple Case Study in Finland

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### 1 Introduction

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

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

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

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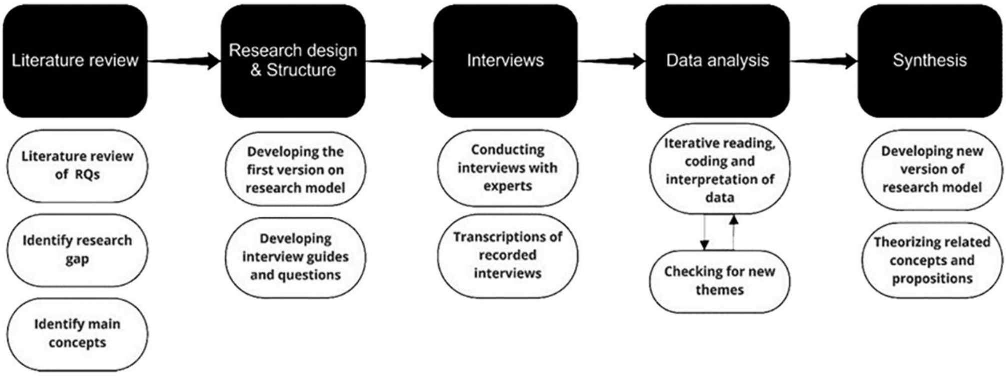


FIGURE 3.1 Research steps of the study.

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

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

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

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

## 2 Background

### *2.1 AI as an Enabler of CE*

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

### *2.2 Role of Entrepreneurship in CE*

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

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

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

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

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

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

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

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

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

Recent studies identifies that "entrepreneurship, innovation, and socio-economic development" increases circularity significantly. (Kostakis and Tsagarakis, 2022). Kostakis and Tsagarakis (2022), realize that the above elements have positive impacts on circularity. According to their findings, 1% increase in entrepreneurship in Europe increases circularity rate by 0.19% whereas 1% increase of research and development which leads to innovative solutions enhances circularity rate by 0.65% on average. On the other hand, 1% increase of economic growth increases circularity rate annually by 0.73%. Therefore, by providing more opportunities for entrepreneurship in Europe, innovation level will rise and leads to an advancement in socio-economic matters which all in return leads to faster progress in circularity. However, there is limited literature on how entrepreneurs adapt DTs such as AI to provide innovative solutions for circularity. Therefore, this study aims to fill this gap by analyzing cases that implement innovative circular solutions and examining their current situation in adaptation of AI. (Kostakis and Tsagarakis, 2022). Entrepreneurially inclined individuals drive collaborations by sharing a vision, enthusiasm, and importantly, a convincing proposition for a CE. Moreover, collaboration is pursued at an early stage to co-develop the problem and solution space and to integrate diverse knowledge from across the value network, thereby mitigating increased complexity (Brown et al., 2019). Additionally, sustainable entrepreneurship can advocate for changes in institutional structures, enabling the exploitation of sustainable opportunities, enhancing the competitiveness of sustainable behaviors, and fostering new entrepreneurial mindsets. This approach not only promotes sustainability but also encourages innovation and entrepreneurial spirit.

## 3 Research Methodology

### *3.1 Research Design*

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

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

### *3.2 Data Collection*

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

**TABLE 3.2** Case company details including circular objectives and BMs

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

**TABLE 3.2** (Continued)

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

*Abbreviation*: BMs, business models.

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

### *3.3 Data Analysis*

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

## 4 Results and Discussions

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

**TABLE 3.3** DTs and CE strategies of case companies

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

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

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

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

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

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

As presented in Table 3.4, data plays essential role in tracking lifecycle of the products. Moreover, the interviewees described the enablers of their business factors such as global megatrend of climate change, the pressure towards producers for their impacts of activities for supplying raw materials on climate and increasing consumer awareness about climate change. For example, the enabler of the Emmy start-up has been the global warming and high emission of fashion industry, challenges and complexity in recycling of textiles, difficulty to access flea markets, and the need for a safe, risk-free seller–customer marketplace in which products are curated. Hence, digital platforms can be considered as a suitable and practical solution in enabling CE and AI can play crucial role in this case. The value of digitalization of the processes is evident for all the companies especially since the conventional data collection is costly, not efficient, and not accurate. There is still a lack of direct integration of data to the systems while data is exchanged mostly through google sheet. On the other hand, EU regulations are forcing companies to look for more innovative environmental solutions that are linked to data and require utilization of DTs. In this regard, digitalization and automation of supply chain can help in accessibility of data through the entire value chain, which is currently lacking.

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

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

(*Continued*)

**TABLE 3.5** (Continued)

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

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

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**SUSTAINABLE HORIZONS**

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